U.S. Department of Transportation
Federal Aviation Administration

Advisory Circular

Subject:	FLIGHT TEST GUIDE FOR CERTIFICATION OF PART 23 AIRPLANES	Date:	8/30/93	AC No:	23-8A
		Initiated by:	ACE-100	Change:	1

1. PURPOSE. This change revises existing material in 23 paragra and 2 appendixes.

The change number and the date of the changed material are carried the top of each page. The black line in the right margin indicate the beginning and end of each change. Rearranged pages having no material also carry the change number and new date. Pages having changes retain the same heading information.

2. PRINCIPAL CHANGES.

a. Paragraphs 8, 11, 17, 18, 21, 22, 24, 25, 26, 27, 45, 47, 51, 75, 86, 100, 121, 162, 256, 287, 373, 410, 413, appendix 2, an appendix 5.

b. A new appendix 10 has been added to this AC.

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ILLUSTRATIONS

The first block of digits in the figure number denotes the associated paragraph number. The second block of digits denotes the figure number within the paragraph.

ADVISORY CIRCULARS

ADVISORY CIRCULARS (continued)

ADVISORY CIRCULARS (continued)

(2) Maximum Weieht Exceptions. The regulations concerning design maximum weight allows an exception in that some of the structural requirements may be met at a lesser weight known as a design landing weight which is defined in § 23.473. Also, see Advisory Circular (AC) 23-7 if the airplane is being modified for an increase in maximum weight. The flight requirements also allow an exception to the design maximum weight to the degree described in appendix E to Part 23 of the FAR, which deals with airplanes equipped with standby power rocket engines.

(3) Weinht. Altitude. Temperature (WAT). For turbine-powered multiengine normal, utility, and acrobatic category airplanes, a WAT offload chart may be used as a maximum weight limitation, if the high altitude and high temperature requirement of §§ 23.65(c), 23.67(c)(2), or 23.77(b) limits the maximum weight. The performance weight limitations for commuter category airplanes are specified in § 23.1583(c)(3).

(4) Ramp Weight. The applicant may elect to use a "ramp weight" provided compliance is shown with each applicable section of Part 23 of the FAR. Ramp weight is the takeoff weight at brake release plus an increment of fuel weight consumed during engine start, taxiing, and runup. Generally, this increment of fuel should not exceed 1% of the maximum permissible flight weight. The pilot should be provided a means to reasonably determine the airplane gross weight at brake release for takeoff. A fuel totalizer is one way of providing the pilot with fuel on board. Alternately, a mental calculation by the pilot may be used, if the pilot is provided the information to make the calculation and the calculation is not too complex. Normally, fuel for engine start and runup will be sufficiently close to a fixed amount that taxi can be considered as the only variable. If the pilot is provided with taxi fuel burn rate in lbs./minute, then the resulting mental calculation is acceptable. The pilot will be responsible to ensure that the takeoff gross weight limitation is complied with for each takeoff, whether it be limited by altitude, temperature, or other criteria. The maximum ramp weight should be shown as a limitation on the Type Certificate (TC) Data Sheet and in the AFM.

(5) Lowest Maximum Weight. Based on an FAA General Counsel decision of August 1977, §§ 23.25(a)(2)(i) and 23.25(a)(2)(ii) require that each of the two conditions, (i) and (ii), must be considered and that the maximum weight, as established, not be less than the weight under either condition.

(6) Placarding: of Seats. When establishing a maximum weight in accordance with § 23.25(a)(2)(i), one or more seats may be placarded to a weight of less than 170 pounds (or less than 190 pounds for utility and acrobatic category airplanes). An associated requirement is § 23.1557(b). The AFM loading instructions, required by § 23.1589(b), should be specific in addressing the use of the placarded seats.

b. Procedures. None.

9. SECTION 23.29 (as amended bv amendment 23-21) EMPTY WEIGHT AND CORRESPONDING CENTER OF GRAVITY.

a. Explanation.

(1) Fixed Ballast. Fixed ballast refers to ballast that is made a permanent part of the airplane as a means of controlling the c.g.

(2) Equipment List. Compliance with § 23.29(b) may be accomplished by the use of an equipment list which defines the installed equipment at the time of weighing and the weight, arm, and moment of the equipment.

b. Procedures. For prototype and modified test airplanes, it is necessary to establish a known basic weight and c.g. position (by weighing) from which the extremes of weight and c.g. travel required by the test program may be calculated. See AC 91-23A, Pilot's Weight and Balance Handbook, for sample weight and balance procedure. Normally, the test crew will verify the calculations.

10. SECTION 23.31 (as amended bv amendment 23-13) REMOVABLE BALLAST.

a. Explanation. This regulation is associated only with ballast which is installed in certificated airplanes under specified conditions. The ballasting of prototype airplanes so that flight tests can be conducted at certain weight and c.g. conditions is covered under § 23.21, paragraph 6, of this AC.

b. Fluid Cargo. For those airplanes configured to carry fluid cargo (such as agricultural chemical tanks, minnow tanks, slurry tanks, etc.), airplane handling qualities should be investigated with full and the most critical partial fluid loads. Also, when so equipped, the effects of in-flight jettison or dumping of the fluid load should be evaluated.

11. SECTION 23.33 (original issue) PROPELLER SPEED AND PITCH LIMITS.

a. General. Section 23.33(a) requires that propeller speed and pitch be limited to values that will ensure safe operation under normal operating conditions.

b. Procedures. Assuming that both the tachometer and the airspeed indicator system of the test airplane have been calibrated within the past 30 days and that the best rate of climb speed is known, the following appropriate tests should be conducted:

(1) Fixed Pitch Propellers.

(i) Maximum Revolutions per Minute (R.P.M.). The regulation is self-explanatory.

(ii) Static R.P.M. Determine the average static r.p.m. with the airplane stationary and the engine operating at full throttle under a no-wind condition. The mixture setting should be the same as used for maximum r.p.m. determination. If the wind is light (5 knots or less), this static r.p.m. can be the average obtained with a direct crosswind from the left and a direct crosswind from the right.

(iii) Data Sheet R.P.M. Determination. For fixed pitch propellers, the static r.p.m. range is listed in the TC Data Sheet; for example, not more than 2200 r.p.m. and not less than 2100 r.p.m. The allowable static r.p.m. range is normally established by adding and subtracting 50 r.p.m. to an average no-wind static r.p.m. An applicant may desire to obtain approval for one or more additional propellers and retain only one r.p.m. range statement. An applicant may also choose to extend the propeller's static r.p.m. range.

(A) Lower R.P.M. The static r.p.m. range may be extended on the low side by obtaining approval for a propeller with a lower static r.p.m. In this case, the approval must be accomplished with due consideration of performance requirements. The airplane with the new propeller installed must be able to meet the minimum climb performance requirements.

(B) Higher R.P.M. If the static r.p.m. range is to be extended upward, the new propeller would have to be tested to ensure that it did not cause an engine speed above 110% of maximum continuous speed in a closed throttle dive at the never-exceed speed. It must not exceed the rated takeoff r.p.m. of the engine up to and including the best rate of climb speed of the airplane. An engine cooling climb test may also be required due to the additional power produced by the faster turning propeller.

(2) Controllable Pitch Propellers Without Constant Speed Controls.

(i) Climb R.P.M. With the propeller in full low pitch, determine that the maximum r.p.m. during a climb using maximum power at the best rate of climb speed does not exceed the rated takeoff r.p.m. of the engine.

(ii) Dive R.P.M. With the propeller in full high pitch, determine that the closed throttle r.p.m. in a dive at the never-exceed speed is not greater than 110% of the rated maximum continuous r.p.m. of the engine.

(3) Controllable Pitch Propellers With Constant Speed Controls.

(i) Climb R.P.M. With the propeller governor operative and prop control in full high r.p.m. position, determine that the maximum power r.p.m. does not exceed the rated takeoff r.p.m. of the engine during takeoff and climb at the best rate of climb speed.

(ii) Static R.P.M. With the propeller governor made inoperative by mechanical means, obtain a no-wind static r.p.m.

(A) Reciprocating Engines. Determine that the maximum power static r.p.m., with the propeller blade operating against the low pitch stop, does not exceed 103% of the rated takeoff r.p.m. of the engine.

(B) Turbopropeller Engines. Although this rule references manifold pressure, it has been considered to be applicable to turbopropeller installations. With the governor inoperative, the propeller blades at the lowest possible pitch, with takeoff power, the airplane stationary, and no wind, ensure that the propeller speed does not exceed the maximum approved engine and propeller r.p.m. limits. Propellers that go to feather when the governor is made inoperative need not be tested.

(iii) Safe Operation Under Normal Operating Conditions.

(A) Reciprocating Engines. Descent at V_{NE} or V_{MO} with full power, although within the normal operating range, is not a normal operating procedure. Engine r.p.m., with propeller on the high pitch blade stops, that can be controlled by retarding the throttle may be considered as acceptable in showing compliance with § 23.33(a).

(B) Turbopropeller Engines. Perform a maximum r.p.m. at maximum torque (or power) descent at V_{MO} to ensure that normal operating limits for the propeller are not exceeded.

(4) Data Acquisition and Reduction. The observed r.p.m. data in each case must be corrected for tachometer error. The airspeed system error must also be taken into consideration to determine the proper calibrated airspeed. True airspeed may also need to be considered because propeller angle of attack is a function of true airspeed.

12.-15. RESERVED.

Section 2. PERFORMANCE

16. SECTION 23.45 (as amended by amendment 23-34) GENERAL.

a. Explanation.

(1) Atmospheric Standards. The purpose of § 23.45(a) is to set the atmospheric standards in which the performance requirements should be met. The air should be smooth with no temperature inversions, mountain waves, etc. This is essential to obtaining good data and repeatable results. Nonstandard conditions of temperature, pressure, etc., can be corrected to standard, but there are no corrections to compensate for poor quality data due to turbulence or poor pilot technique. A thorough knowledge of the limitations of the testing procedures and data reduction methods is essential so that good engineering judgment may be used to determine the acceptability of any tests.

(i) Normal. Utility. and Acrobatic Category Airplane. Performance tests will normally be conducted in nonstandard atmospheric conditions, but ideally for accuracy in data reduction and expansion, tests should be conducted in still air and atmospheric conditions as near those of a standard atmosphere as possible. Accounting for winds and nonstandard conditions requires testing procedures and data reduction methods that reduce the data to still air and standard atmospheric conditions.

(ii) Commuter Category Airplanes. Performance tests should be conducted in the range of atmospheric conditions that will show compliance with the selected weight, altitude, and temperature limits. See paragraph 19 of this AC for guidance on extrapolation of takeoff data and paragraph 27 for extrapolation of landing data.

(2) Standard Atmosphere. The standard atmosphere is defined in Part 1 of the FAR as the U.S. Standard Atmosphere, 1962 (geopotential altitude tables). The U.S. Standard Atmosphere is identical to the International Civil Aviation Organization (ICAO) Standard Atmosphere for altitudes below 65,000 feet. Appendix 7, figure 1, gives properties of the U.S. Standard Atmosphere in an abbreviated format.

(3) Installed Power. The installed propulsive horsepower/thrust of the test engine(s) may be determined using the applicable method described in appendix 1. The methods in appendix 1 account for installation losses and the power absorbed by accessories and services. Consideration should also be given to the accuracy of the power setting instruments/systems, and the pilot's ability to accurately set the power/thrust.

(2) Test.

(i) Stall Speed. The actual test should be commenced with the airplane in the configuration desired and trimmed at approximately 1.5 V_{S1} or the minimum speed trim, whichever is greater. The airplane should be slowed to about 10 knots above the stall, at which time the speed should be reduced at a rate of one knot per second or less until the stall occurs or the control reaches the stop. Where exact determination of stalling speed is required, entry rate should be varied to bracket one knot per second, and data should be recorded to allow the preparation of time histories similar to those shown in figure 17-1. The indicated airspeed at the stall should be noted, using the production airspeed system. Both the indicated airspeeds and the calibrated stall speeds may then be plotted versus entry rate to determine the one knot per second values.

(ii) Bomb. When using a bomb, caution should be used in recovering from the stall so that the bomb is not whipped off the end of the hose.

(iii) Weight and C.G. The stalling speed should be determined at all weight and c. g. positions defining the corners of the loading envelope to determine the critical condition. The highest stall speed for each weight will be forward c.g. in most cases. Data should be recorded so that the weight and c.g. at the time of the test can be accurately determined. This can often be done by recording the time of takeoff, time of test, time of landing, and total fuel used during the flight.

(iv) Power and Configuration. The stall should be repeated enough times for each configuration to ensure a consistent speed. If a correction is to be made for zero thrust, then the stall speed and power at several power settings may be recorded for later extrapolation to zero thrust.

(v) Control Stops. The elevator up stop should be set to the minimum allowable deflection. Flap travels should be set to minimum allowable settings.

(3) Data Reduction. The correction involves:

(i) Correction for airspeed error – IAS to CAS (correct for instrument as well as position error) when CAS is required.

(ii) Correction for weight - multiply the test calibrated stall speed times the square root of the standard weight divided by the test weight.

$$V_S = V_{st}\sqrt{\frac{W_s}{W_t}}$$

Where V_s = Stall speed (CAS)

V_{st} = Test stall speed (CAS)

W_s = Standard weight (lbs.)

W_t = Test weight (lbs.)

(CAUTION -- Do not use for minimum steady flight speed)

(iii) The correction for weight shown above applies only where the c.g. is not also changing with weight. Where c.g. is changing with weight, such as between forward regardless and forward gross, stall speed should account for this. A straight line variation between the measured stall speeds for the two weight and c.g. conditions has been found to be an acceptable method.

18. SECTION 23.51 (as amended by amendment 23-21) TAKEOFF - NORMAL, UTILITY, AND ACROBATIC CATEGORY AIRPLANES.

a. Explanation.

(1) Objective of Takeoff Requirement. The primary objective of the takeoff requirement is to establish, for information of the operator, a takeoff distance within which the airplane may be expected to achieve a speed and height sufficient *to* ensure capability of performing all maneuvers that may become necessary for safe completion of the takeoff, and for safe landing if necessitated by power failure. An airspeed margin above stall in conjunction with a height of 50 feet is presumed to assure the desired maneuvering capability.

(2) Multiengine 50-foot Speed. For multiengine airplanes, § 23.51(c)(1) requires the speed at the 50-foot point to be the higher of:

(i) 1.1 V_{MC}, or

(ii) 1.3 V_{S1}, or any lesser speed, down to V_X + 4 knots.

(3) Single Engine 50-foot Speed. For single-engine airplanes, § 23.51(c)(2) requires the speed at the 50-foot point to be:

(i) 1.3 V_{S1}, or

(ii) any lesser speed, down to V_X + 4 knots.

(4) Takeoff Speed Investigations - General.

(i) For those airplanes in which the takeoff distance is based on the 1.3 V_{S1} speed corresponding to maximum takeoff weight, no further consideration of the acceptability of such speed is generally necessary, except for investigating the handling characteristics with maximum approved fuel unbalance.

(ii) Specific investigations for acceptability of the takeoff speed should be made for all airplanes for which the takeoff distance is based on a speed less than the 1.3 V_{S1} speed. Investigation of the acceptability of the takeoff speed, and of the associated takeoff procedure, should include a demonstration that controllability and maneuverability in the takeoff configuration are adequate to safely proceed with the takeoff in turbulent crosswind conditions and maximum approved lateral fuel unbalance.

(5) Single-engine Airplane Takeoff Speeds. The takeoff speed investigation should include demonstration that controllability and maneuverability following engine failure at any time between lift-off and the 50-foot point are adequate for safe landing. Applicants are encouraged to schedule both a rotation speed and a speed for 50-foot height. If a single speed has been chosen for lift-off and climb-out to 50-foot height, the resulting airplane deck angle may be too high to successfully accomplish a safe landing.

(6) Multiengine Airplane Takeoff Speeds. For multiengine airplanes, the investigation should include a demonstration that the controllability and maneuverability following critical engine failure at any time between lift-off and the 50-foot point are adequate for either safe landing or for safe continuation of the takeoff. There will be some combinations of weight, altitude, and temperature where positive climb at the 50-foot height with one engine inoperative is not possible. Because of this, a satisfactory re-land maneuver should be demonstrated. Applicants are encouraged to schedule both a rotation speed and a speed for 50-foot height. Rotation speed should be scheduled so that V_{LOF} is not less than V_{MC}, in accordance with § 23.51(b). If a single speed has been chosen for lift-of and climb-out to 50-foot height, the resulting airplane deck angle may be too high to successfully accomplish a safe landing.

(7) Multiple Takeoff Weights. For those multiengine airplanes for which takeoff distance data are to be approved for a range of weights, and for which the takeoff distance is based upon takeoff speeds which decrease as the weight decreases, the investigations of paragraph (4) of this section also should include consideration of the minimum control speed, V_{MC}. The 1.2 V_S design limit imposed on V_{MC} by § 23.149 is intended to provide a controllability margin below the takeoff speed that is sufficient for adequate control of the airplane in the event of engine failure during takeoff. Hence, to maintain the intended level of safety for the lower takeoff speeds associated with the lighter takeoff weights, investigation of the acceptability of such speeds for compliance with § 23.51(c)(1) should include demonstration of acceptable characteristics following engine failure at any time between lift-off and the 50-foot. point during takeoff in accordance with the established takeoff procedures.

(8) Complete Engine Failure. The term, "complete engine failure," as used in § 23.51(c)(1), was defined in the preamble to amendment 23-21. The pertinent portion of the preamble is as follows:

> ". . . current section 23.51(a)(2)(ii) has been consistently interpreted to require that for multiengine airplanes which meet the powerplant isolation requirements of section 23.903(c) in the takeoff configuration, only one engine need be made inoperative in the specified investigations."

(9) AFM Takeoff Distance. Section 23.1587(a)(5) requires the takeoff distance determined under § 23.51 to be furnished in the AFM. The data should be furnished at the most critical c.g. (usually forward). Section 23.1587(a)(8) further requires the calculated approximate effect of altitude from sea level to 8000 feet and temperature from ISA - 60°F to ISA + 40°F be furnished in the AFM. Propulsive thrust available should be accounted for in accordance with § 23.45 and appendix 1 of this AC. For turbine-powered airplanes, distances should be presented up to the maximum takeoff temperature limit. A data expansion method appropriate to the airplane's features should be used.

(10) AFM Takeoff Technique. For multi-engine airplanes, § 23.1585(c)(4) requires the AFM to furnish the procedures for the § 23.51 takeoff. The recommended technique that is published in the AFM and used to achieve the performance should be one that the operational pilot can duplicate using the minimum amount of type design cockpit instrumentation and the minimum crew.

(11) Tire Speed Limits. If TSO'd tires are used, it should be determined that, within the weight, altitude, and temperature for which takeoff performance is shown in § 23.1587, that the TSO tire speed ratings are not exceeded at V_{LOF}. If the tire speed rating would be exceeded under some combinations of weight, altitude, and temperature, then the tirespeed limit should be established as an operating limitation, and a maximum takeoff weight limited by tire speed chart should be included in the AFM performance section in compliance with § 23.1581(a)(2).

b. Procedures.

(1) Takeoff Distance Tests. The takeoff distance should be established by test, and may be obtained either by takeoffs conducted as a continuous operation from start to the 50-foot height, or synthesized from acceleration segments and climb segment(s) determined separately. Recording theodolite or electronic equipment that is capable of providing horizontal distance and velocity, and height above the takeoff surface, is highly desirable for takeoff distance tests. Additional required special ground equipment includes a sensitive anemometer capable of providing wind velocity and direction, a thermometer capable of providing accurate free-air temperature under all conditions, and an altimeter or barograph to provide pressure altitude.

(2) Segment Technique. For the segment technique, the airplane should be accelerated on the surface from brake release to rotation speed (V_R) and on to the speed selected for the 50-foot height point. Six acceptable runs are recommended to establish the takeoff acceleration segment. V_R should be selected so that the 50-foot speed can be achieved. A climb segment based on the rate of climb, free of ground effect, is added to the acceleration segment. See paragraph 25 of this AC and appendix 2 for climb performance methods. Total distance is the sum of the acceleration segment plus the climb segment. For AFM presentation, the ground run would be the ground acceleration distance to V_{LOF}, and the air distance would be the horizontal distance to climb at the 50-foot speed for 50 feet plus the ground acceleration distance from V_{LOF} to the 50-foot speed. For those airplanes with retractable gear, the landing gear should be extended throughout, or alternatively, retraction may be initiated at a speed corresponding to a safe speed for gear retraction following lift-off in normal operations. If takeoff distance is determined using the "segmented" method, actual takeoffs using the AFM takeoff speed schedule should be conducted to verify that the actual takeoff distance to the 50-foot height does not exceed the calculated takeoff distance to the 50-foot height.

(3) Weight. Takeoff distance tests should be conducted at the maximum weight, and at a lesser weight if takeoff distance data for a range of weights is to be approved. The test results may be considered acceptable without correction for weight if a ±0.5% weight tolerance is observed.

(2) In conducting the flight tests required by § 23.53(c)(6), the test pilot should use a normal/natural rotation technique as associated with the use of scheduled takeoff speeds for the airplane being tested. Intentional tail or tail skid contact is not considered acceptable. Further, the airspeed attained at a height of 35 feet during this test is required to be not less than the scheduled V_2 value minus 5 knots. These speed limits should not be considere or utilized as target V_2 test speeds, but rather are intended to provide an acceptable range of speed departure below the scheduled V_2 value.

(3) In this abuse test, the engine cut should be accomplished prior to the V_R test-speed (i.e., scheduled V_R-5 knots) to allow for engine spin-down. The normal one-engine-inoperative takeoff distance may be analytically adjusted to compensate for the effect of the early engine cut. Further, in those tests where the airspeed achieved at a height of 35 feet is slightly less than the V_2-5 knots limiting value, it is permissible, in lieu of reconducting the tests, to analytically adjust the test distance to account for the excessive speed decrement.

(C) All-engines-operating abuse tests.

(1) Section 23.53(c)(7) requires that there not be a "marked increase" in the scheduled takeoff distance when reasonably expected service variations such as early and excessive rotation and out-of-trim conditions are encountered. This is considered as requiring takeoff tests with all engines operating with:

(i) An abuse on rotation speed, and

(ii) out-of-trim conditions but with rotation at the scheduled V_R speed.

NOTE: The expression "marked increase" in the takeoff distance is defined as any amount in excess of 5% of the takeoff distance as determined in accordance with §23.59. Thus, the abuse tests should not result in a takeoff distance of more than 105% of the scheduled takeoff distance.

(2) For the early rotation abuse condition with all engines operating and at a weight as near as practicable to the maximum sea level takeoff weight, it should be shown by test that when the airplane is over-rotated at a speed below the scheduled V_R, no "marked increase" in the takeoff distance will result. For this demonstration, the airplane should be rotated at a speed of 10 knots or 7%, whichever is less, below the scheduled V_R. Tests should be conducte at a rapid rotation rate or should include an over-rotation of 2 degrees above normal attitude after liftoff. Tail strikes, should they occur during this demonstration, are acceptable only if a fault analysis (structural, electrical, hydraulic, etc.) has been accomplished and indicates no possible degradation in the control of aircraft, engines, or essential systems necessary for continued safe flight after a reasonable, worst case tail strike.

(3) For out-of-trim conditions with all engines operating and at a weight as near as practicable to the maximum sea level takeoff weight, it should be shown that with the airplane mistrimmed, as would reasonably be expected in service, there should not be a "marked increase" in the takeoff distance when rotation is initiated in a normal manner at the scheduled V_R speed. For those airplanes with an allowable takeoff trim band, the amount of mistrim used should be with the longitudinal control trimmed to its most adverse position within the allowable takeoff trim band as shown on the cockpit indicator. For those airplanes without an allowable takeoff trim band, the amount of mistrim to be reasonably expected in service will be a pilot judgment.

21. SECTION 23.55 (as added by amendment 23-34) ACCELERATE-STOP DISTANCE.

a. Explanation. This section describes test demonstrations necessary to determine accelerate-stop distances for airplane performance required to be published in the Performance Section of the AFM.

b. Procedures.

(1) Accelerate-stop tests should be determined in accordance with the provisions of this paragraph.

(i) Number of Test Runs. A sufficient number of test runs should be conducted for each airplane configuration desired by the applicant, in order to establish a representative distance that would be required in the event of a rejected takeoff at or below the takeoff decision speed V,.

(ii) Time Delays. The procedures outlined in paragraph 21b(12), as required by § 23.45(f)(5), apply appropriate time delays for the execution of retarding means related to the accelerate-stop operation procedures and for expansion of accelerate-stop data to be incorporated in the AFM.

(iii) Reverse Thrust. The stopping portion of the accelerate-stop test may not utilize propeller reverse thrust unless the thrust reverser system is shown to be safe, reliable, and capable of giving repeatable results. See subparagraph c.

(2) Airport Elevation. Accelerate-stop runs at different airport elevations can be simulated at one airport elevation provided the braking speeds used include the entire energy range to be absorbed by the brakes. In scheduling the data for the AFM, the brake energy assumed should not exceed the maximum demonstrated in these tests.

(3) Braking Speeds. The braking speeds referred to herein are scheduled *test* speeds and need not correspond to the values to be scheduled in the AFM, since it is necessary to increase or decrease the braking speed to simulate the energy range and weight envelope.

(4) Number of Runs. At least two test runs are necessary for each configuration when multiple aerodynamic configurations are being shown to have the same braking coefficient of friction, unless sufficient data is available for the airplane model to account for variation of braking performance with weight, kinetic energy, lift, drag, ground speed, torque limit, etc. These runs should be made with the airplane weight and knetic energy varying throughout the range for which takeoff data is scheduled. This will usually require at least six test runs. These tests are usually conducted on hard surfaced, dry runways.

(5) Alternate Approvals. For an alternate approval with antiskid inoperative, nose wheel brakes or one main wheel brake inoperative, autobraking systems, etc., a full set of tests, as mentioned in paragraph 21b(4), should normally be conducted. A lesser number of tests may be accepted for "equal or better" demonstrations, or to establish small increments, or if adequate conservatism is used during testing.

(6) Maximum Enerev Stop. A brake energy demonstration is needed to show compliance with the brake energy requirements. A maximum energy stop (or some lesser brake energy) is used to establish a distance that can be associated with the demonstrated kinetic energy. An applicant can choose any level of energy for demonstration providing that the AFM does not show performance beyond the demonstrated kinetic energy. The demonstration should be conducted at not less than maximum takeoff weight and should be preceded by a 3-mile taxi, including three full stops using normal braking and all engines operating. Propeller pitch controls should be applied in a manner which is consistent with procedures to be normally used in service. Following the stop at the maximum kinetic energy level demonstration, it is not necessary for the airplane to demonstrate its ability to taxi. The maximum kinetic airplane energy at which performance data is scheduled should not exceed the value for which a satisfactory afterstop condition exists. A satisfactory afterstop condition is defined as one in which fires are confined to tires, wheels, and brakes, and which would not result in progressive engulfment of the remaining airplane during the time of passenger and crew evacuation. The application of fire fighting means or artificial coolants should not be required for a period of five minutes following the stop.

(7) Maximum Enerev Stop from a Landing. In the event the applicant proposes to conduct the maximum energy RTO demonstration from a landing, a satisfactory accounting of the brake and tire temperatures that would have been generated during taxi and acceleration, required by paragraph 21b(6), should be made.

(8) Either ground or airborne instrumentation should include a means to determine the horizontal distance-time history.

(9) Wind Speed. The wind speed and direction relative to the active runway should be determined. The height of the wind measurement should be noted, to facilitate corrections to airplane wing level.

(10) Configurations. The accelerate-stop tests should be conducted in the following configurations:

(i) Heavy to light weight as required.

(ii) Most critical c.g. position.

(iii) Wing flaps in the takeoff position(s).

(iv) Tire pressure: before taxi and with cold tires, set to the highest value appropriate for the takeoff weight for which approval is being sought.

(v) Engine: set r.p.m. at applicant's recommended upper idle power limit, or the effect of maximum idle power may be accounted for in data analyses. Propeller condition should also be considered. See discussion in subparagraph (11), Engine Power.

(11) Engine Power. Engine power should be appropriate to each segment of the rejected takeoff and account for thrust decay times. See discussion of § 23.57(a)(2) in paragraph 22c(1). At the selected speed that corresponds to the required energy, the airplane is brought to a stop employing the acceptable braking means. The critical engine's propeller should be in the position it would normally assume when an engine fails and the power levers are closed.

(i) High Drag Propeller Position. The high drag position (not reverse) of the remaining engines' propellers may be utilized provided adequate directional control can be demonstrated on a wet runway. Simulating wet runway controllability by disconnecting the nose wheel steering may be used. The use of the higher propeller drag position (i.e., ground fine) is conditional on the presence of a throttle position which incorporates tactile feel that can consistently be selected in service by a pilot with average skill. It should be determined whether the throttle motions from takeoff power to this ground fine position are one or two distinctive motions. If it is deemed to be two separate motions, then accelerate-stop time delays should be determined accordingly and applied to expansion of data.

(ii) Reverse Thrust. See subparagraph c for discussion of when reverse thrust may be used. Demonstration of full single engine reverse controllability on a wet runway and in a 10 knot adverse crosswind will be required. Control down to zero speed is not essential, but a cancellation speed based on controllability can be declared and credit given for use of reverse above that speed. The use of reverse thrust on one engine on a wet runway requires that the reverse thrust component be equally matched by a braking component and rudder use on the other side. Experience has shown that using reverse with one engine inoperative, requires brakes to be modulated differently between left and right while applying only partial reverse thrust, even on dry pavement. Disconnecting nose wheel steering will not adequately simulate a wet runway for a full reverse condition. The use of a reverse thrust propeller position is conditional on the presence of a throttle position which incorporates tactile feel that can consistently be selected in service by a pilot with average skill. Selection of reverse thrust from take-off power typically requires the power level to be retarded to idle, a gate or latching mechanism to be overcome and the power lever to be further retarded into the ground/reverse range. This is interpreted as three "distinctive motions," with each regarded as activation of a separate deceleration device. Accelerate-stop time delays should be determined accordingly and applied to expansion of data.

(12) Accelerate-Stop Time Delays. Figure 21-1 is an illustration of the accelerate-stop time delays considered acceptable for compliance with § 23.45:

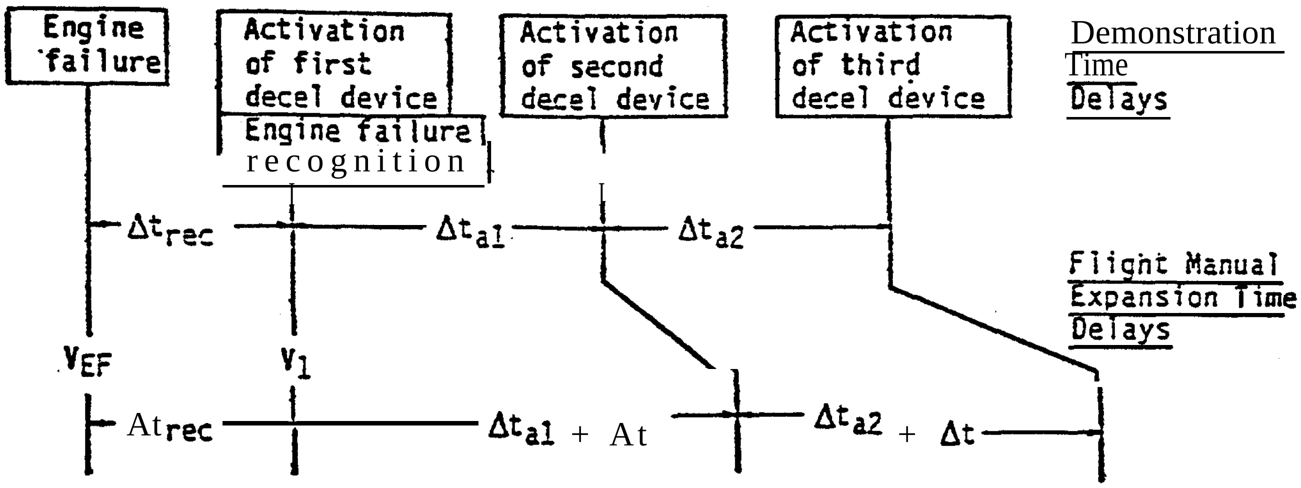


Figure 21-1 - ACCELERATE-STOP TIME DELAYS

(i) Δt_{rec} = engine failure recognition time. The demonstrated time from engine failure to pilot action indicating recognition of the engine failure. For AFM data expansion purposes, it has been found practical to use the demonstrated time or 1 second, whichever is greater, in order to allow a time which can be executed consistently in service.

(ii) Δt_{a1} = the demonstrated time interval between activation of the first and second deceleration devices.

(iii) Δt_{a2} = the demonstrated time interval between activation of the second and third deceleration devices.

(iv) Δt = a l-second reaction time delay to account for in-service variations. For AFM calculations, airplane deceleration is not allowed during the reaction time delays. If a command is required for another crewmember to actuate a deceleration device, a 2-second delay, in lieu of the l-second delay, should be applied for each action. For automatic deceleration devices which are approved for performance credit for AFM data expansion, established times determined during certification testing may be used without the application of additional time delays required by this paragraph.

(v) The sequence for activation of deceleration devices may be selected by the applicant. If, on occasion, the desired sequence is not achieved during testing, the test need not be repeated; however, the demonstrated time interval may be used.

(13) The procedures used to determine accelerate-stop distance should be described in the Performance Information Section of the AFM.

c. Use of Reverse Thrust. Section 23.55(b) permits means other than wheel brakes to be used in determining the stopping distance, when the conditions specified in § 23.55(b) are met. One of the conditions is that the means be safe and reliable.

(1) Reliable. Compliance with the "reliable" provision of the rule may be accomplished by an evaluation of the pitch changing/reversing system in accordance with § 23.1309. The methods of AC 23.1309-l should be used in the evaluation even though type-certificated engine or propeller systems may not have been subjected to the AC 23.1309-l analysis during certification. Additionally, Society of Automotive Engineers (SAE) document ARP-926A, "Fault/Failure Analysis Procedure," will assist in conducting reliability and hazard assessments. Additionally, § 23.1309(d) requires the system to be designed to safeguard against hazards to the airplane in the event the system or any component thereof malfunctions or fails. An acceptable means for showing compliance with the requirement would be to conduct a Failure Modes and Effects Analysis (FMEA) of the system. An acceptable analysis would show that the effects of any system or component malfunction or failure would not result in a hazard to the airplane and that the propeller reversing system is reliable. SAE document, ARP-926A, "Fault/Failure Analysis Procedure," contains acceptable criteria for conducting such an analysis.

Safe and reliable also means that it is extremely improbable that the system can mislead the flight crew or will allow gross asymmetric power settings, i.e., forward thrust on one engine vs. reverse thrust on the other. In achieving this level of reliability, the system should not increase crew work load or require excessive crew attention during a very dynamic time period. Also, the approved performance data should be such that the average pilot can duplicate this performance by following the AFM procedures.

(2) Safe. Compliance with the "safe" provisions of § 23.75(f)(l) will require an evaluation of the complete system including operational aspects to ensure no unsafe feature exists.

22. SECTION 23.57 (as added bv amendment 23-34) TAKEOFF PATH.

a. Section 23.57(a).

(1) Exnlanation.

(i) The takeoff path requirements of § 23.57 and the reductions required by § 23.61 are established so that the AFM performance can be used in making the necessary decisions relative to takeoff weights when obstacles are present. Net takeoff flight path data should be presented in the AFM for information; however, its use is only required for Part 135 operations (reference FAR 135.398(b)).

(ii) The required performance is provided in the AFM by either pictorial paths at various power-to-weight conditions with corrections for wind, or by a series of charts for each segment along with a procedure for connecting these segments into a continuous path.

(2) Procedures.

(i) Section 23.57(a) requires that the takeoff path extend to the higher of where the airplane is 1500 feet above the takeoff surface or to the altitude at which the transition to en route configuration is complete and a speed is reached at which compliance with § 23.67(e)(2) is shown.

(ii) Section 135.398 requires the airplane not be banked before reaching a height of 50 feet as shown by the net takeoff flight path data.

(iii) The AFM should contain information required to show compliance with the climb requirements of §§ 23.57 and 23.67(e)(2). This should include information related to the transition from the takeoff configuration and speed to the en route configuration and speed. The effects of changes from takeoff power to maximum continuous power should also be included.

(iv) Generally, the AFM shows takeoff paths which at low power to weight include acceleration segments between 400 and 1500 feet and end at 1500 feet, and at high power to weight extending considerably higher than 1500 feet above the takeoff surface. On some airplanes, the takeoff speed schedules and/or flap configuration do not require acceleration below 1500 feet, even at limiting performance gradients.

b. Section 23.57(a)(1) - Takeoff Path Power Conditions.

(1) Explanation. The takeoff path established from continuous demonstrated takeoffs should represent the actual expected performance at all points. If the path is constructed by the segmental method, in accordance with §§ 23.57(d)(2) and 23.57(d)(4), it should be conservative and should be supported by at least one demonstrated fly-out to the completed en route configuration. This is necessary to ensure all required crew actions do not adversely impact the required gradients.

(2) Procedures.

(i) To substantiate that the predicted takeoff path is representative of actual performance, the power used in its construction must comply with § 23.45. This requires, in part, that the power for any particular flight condition be that for the particular ambient atmospheric conditions that are assumed to exist along the path. The standard lapse rate for ambient temperature is specified in Part 1 of the FAR under "Standard Atmosphere" and should be used for power determination associated with each pressure altitude during the climb.

(ii) Section 23.57(c)(4) requires that the power up to 400 feet abov the takeoff surface represents the power available along the path resulting from the power lever setting established during the initial ground roll in accordance with AFM procedures. This resulting power should represent the normal expected variations throughout the acceleration and climb to 400 feet and should not exceed the limits for takeoff power at any point.

(iii) A sufficient number of takeoffs, to at least the altitude above the takeoff surface scheduled for V_2 climb, should be made to establish the power lapse resulting from a fixed power ever. An analysis may be used to account for various engine bleeds, e.g., ice protection, air conditioning, etc. In some airplanes, the power growth characteristics are such that less than full rated power is required to be used for AFM takeoff power limitations and performance.

(2) Procedures.

(i) To permit the takeoff to be conducted using less than rated power, automatic power advance devices have been approved. These devices are discussed in a proposed change to Part 23 and various special conditions.

(ii) To permit the takeoff to be based on a feathered propeller up to 400 feet above the takeoff surface, automatic propeller feathering devices have been approved if adequate system reliability has been shown in accordance with § 23.1309. Other automatic systems such as one which minimizes drag of the inoperative propeller by sensing negative torque have also been approved. Drag reduction for a manually feathered propeller is permitted for flight path calculations only after reaching 400 feet above the takeoff surface.

g. Section 23.57(d) - Takeoff Path Construction.

(1) Explanation. This regulation should not be construed to mean that the takeoff path be constructed entirely from a continuous demonstration or entirely from segments. To take advantage of ground effect, typical AFM takeoff paths utilize a continuous takeoff path from V_{LOF} to the gear-up point, covering the range of power-to-weight ratios. From that point, free air performance, in accordance with § 23.57(d)(2), is added segmentally. This methodology may yield an AFM flight path that is steeper with the gear down than up. Section 135.398(e) requires that for net takeoff flight path, the airplane not be banked before reaching a height of 50 feet as shown by the net takeoff flight path. This requires determination of climb data in the wings level condition.

(2) Procedures. The AFM should include the procedures necessary to achieve this performance.

h. Section 23.57(d)(2) - Takeoff Path Segment Conditions.

(1) Explanation. Section 23.57(d)(2) requires that the weight of the airplane, the configuration, and the power setting must be constant throughout each segment and must correspond to the most critical condition prevailing in the segment. The intent is that for simplified analysis, the performance be based on that available at the most critical point in time during the segment, not that the individual variables (weight, approximate power setting, etc.) should each be picked at its most critical value and then combined to produce the performance for the segment.

(2) Procedures. The performance during the takeoff path segments should be obtained using one of the following methods

(i) The critical level of performance as explained in paragraph 22h(1).

(ii) The actual performance variation during the segment.

i. Section 23.57(d)(3) - Segmented Takeoff Path Ground Effect.

(1) Exulanation. See explanation under § 23.57(d). Additionally, this requirement does not intend that the entire flight path necessarily be based upon -out-of-ground-effect performance simply because the continuous takeoff demonstrations have been broken into sections for data reduction expediency. For example, if the engine-inoperative acceleration from V_{EF} to V_R *is* separated into a power decay portion and a windmilling drag portion, the climb from 35 feet to gear up does not necessarily need to be based upon out-of-ground-effect performance, as would be indicated by § 23.57(d)(3), if, in fact, the climb from 35 feet to gear up is within ground effect, as defined by § 23.57(d)(5).

(2) Procedures. None.

j. Section 23.57(d)(4) - Segmented Takeoff Path Check.

(1) Explanation. None.

(2) Procedures, If the construction of the takeoff path from brake release to out-of-ground-effect contains any portions that have been segmented (e.g., airplane acceleration segments of all engines and one-engine inoperative), the path should be checked by continuous demonstrated takeoffs. A sufficient number of these, using the AFM established takeoff procedures and speeds and covering the range of power-to-weight ratios, should be made to ensure the validity of the segmented takeoff path. The continuous takeoff data should be compared to takeoff data calculated by AFM data procedures but using test engine power and test speeds.

k. Turboprop Reduced Power Takeoffs.

(1) Reduced takeoff power is a power less than approved takeoff power for which power setting and airplane performance is established by corrections to the approved power setting and performance. When operating with reduced takeoff power, the power setting which establishes power for takeoff is not considered a limitation.

(2) It is acceptable *to* establish and use a takeoff power setting that is less than the approved takeoff power if:

(i) The establishment of the reduced power takeoff data is handled through the type certification process and contained in the AFM.

(ii) The reduced takeoff power setting:

(A) Does not result in loss of systems or functions that are normally operative for takeoff such as engine failure warning, configuration warning, autofeather, automatic throttles, rudder boost, automatic ignition, or any other safety-related system dependent upon a minimum takeoff power setting.

(B) Is based on an approved engine takeoff power rating for which airplane performance data is approved.

(C) Does not introduce difficulties in airplane controllability or engine response/operation in the event that approved takeoff power is applied at any point in the takeoff path.

(D) Is at least 75% of the approved takeoff power for the ambient conditions.

(E) Is predicated on a careful analysis of propeller efficiency variation at all applicable conditions.

(iii) Relevant speeds used for reduced power takeoffs are not less than those which will show compliance with the required controllability margins with the approved takeoff power for the ambient conditions.

(iv) The AFM states, as a limitation, that reduced takeoff power settings may not be used:

(A) When the antiskid system (if installed) is inoperative.

(B) On wet runways and runways contaminated with snow, slush, or ice, unless suitable performance accountability is made to the increased acceleration and stopping distances on these surfaces.

(v) Procedures for reliably determining and applying the reduced takeoff power value are simple, and the pilot is provided with information to obtain both the reduced power and approved takeoff power for each ambient condition.

(vi) The AFM provides adequate information to conduct a power check, using the approved takeoff power and if necessary, establish a time interval.

(vii) Procedures are given to the use of reduced power.

(viii) Application of reduced power in service is always at the discretion of the pilot.

23. <u>SECTION 23.59 (as added bv amendment 23-34) TAKEOFF DISTANCE AND TAKEOFF RUN.</u>

a. <u>Takeoff Distance - Section 23.59(a)</u>.

(1) <u>Explanation</u>. The takeoff distance is either of the two distances depicted in paragraph 23a(1)(i) or (ii), whichever is greater. The distances indicated below are measured horizontally from the main landing gears at initial brake release to that same point on the airplane when the lowest part of the departing airplane is 35 feet above the surface of the runway and accomplished in accordance with the procedures developed for § 23.57.

(i) The distance measured to 35 feet with a critical engine failure recognized at VL. See figure 23-l.

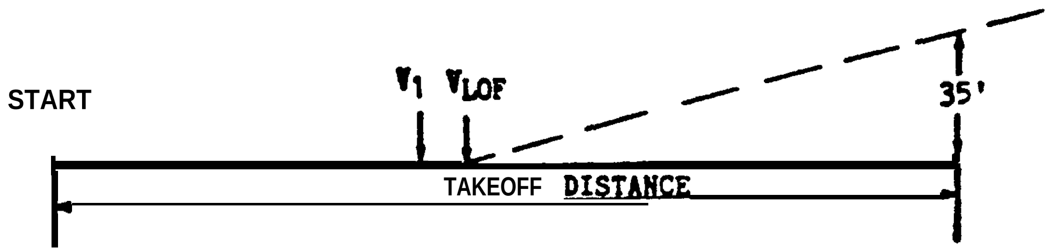


Figure 23-1 - TAKEOFF DISTANCE
Critical Engine Failure Recognized at VL

(ii) One hundred fifteen percent (115%) of the distance measured to 35 feet with all engines operating. See figure 23-2.

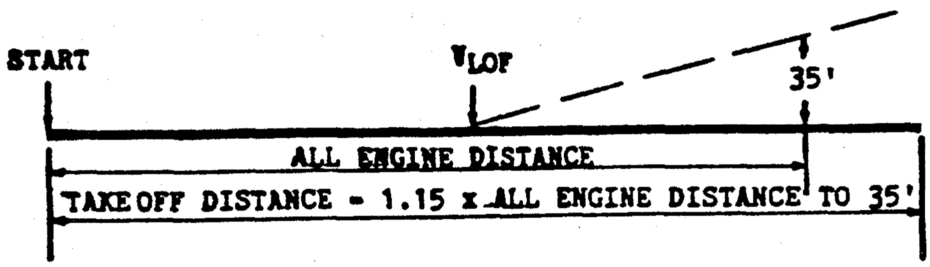
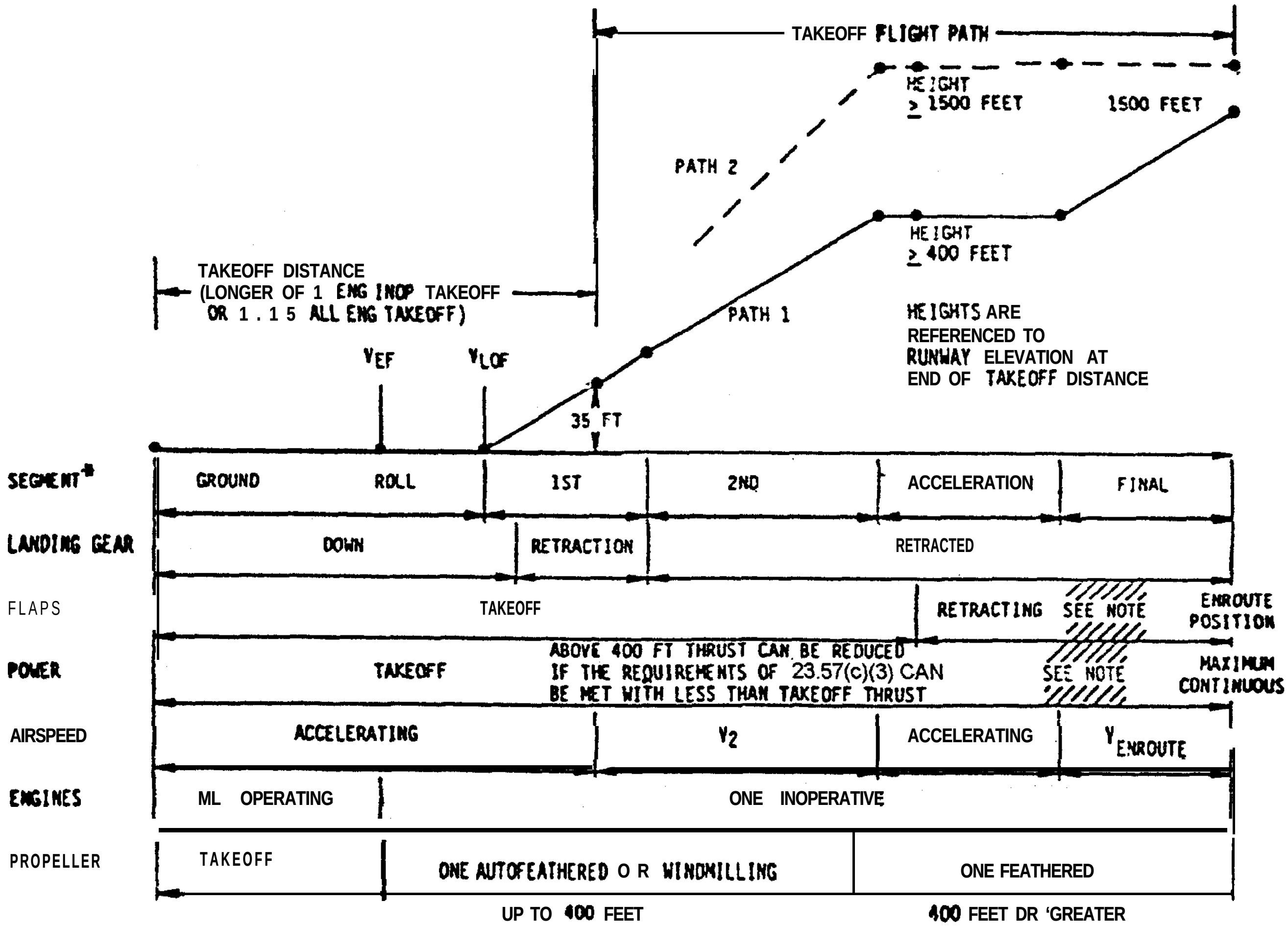


Figure 23-2 - TAKEOFF DISTANCE
All Engines Operating

b. Takeoff Run - Section 23.59(b).

(1) Explanation.

(i) Takeoff run is a term used for the runway length when the takeoff distance includes a clearway (i.e., where the accelerate-go distance does not remain entirely over the runway,), and the takeoff run is either of the two distances depicted in paragraph 23b(1)(i)(A) or (B), whichever is greater. These distances are measured as described in § 23.59(a). Clearways are only defined for turbine-powered airplanes. When using a clearway to determine the takeoff run, no more than one-half of the air distance from V_{LOF} to the 35 foot point may be flown over the clearway.



NOTE. The en route takeoff segment usually begins with the airplane in the en route configuration and with maximum continuous thrust, but it is not required that these conditions exist until the end of the takeoff path when compliance with § 23.67(e)(2) is shown. The time limit on takeoff thrust cannot be exceeded.

* Segments as defined by § 23.67.

Figure 24-1 - TAKEOFF SEGMENTS AND NOMENCLATURE

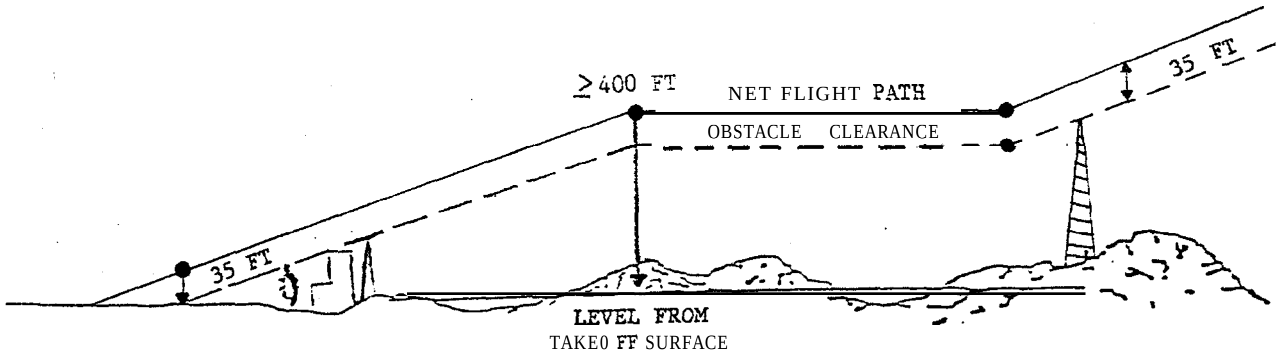


Figure 24-2 - NET TAKEOFF FLIGHT PATH

25. SECTION 23.65 (as amended by amendment 23-34) CLIMB: ALL ENGINES OPERATING.

a. Explanation.

(1) Objectives. The climb tests associated with this requirement are performed to establish the airplane's all-engine performance capability for altitudes between sea level and not less than 8000 feet with wing flaps set to the takeoff position. This is necessary to enable comparison with the minimum climb performance required, and also for AFM presentation of climb performance data of § 23.1587(a)(7) and the effect of altitude and temperature (see § 23.1587(a)(8)) and the effect of weight for commuter category airplanes.

(2) Cooling Climbs. Applicants with single engine reciprocating powered airplanes may vary the climb speeds to meet the requirements of 8 23.1047. If variations in climb speeds are required to meet the cooling tests, the applicant may wish to establish the variation of rate of climb with speed.

(3) Sawtooth Climbs. A common method of determining climb performance is sawtooth climbs. A series of climbs, known as sawtooth climbs, should be conducted at several constant indicated airspeeds using a constant power setting and a prescribed configuration. A minimum of three series of sawtooth climbs should be conducted. The mean altitudes through which the sawtooth climbs are conducted should be:

(i) As near sea level as practical.

(ii) Close to the ceiling (where 100 feet/minute can be maintained) for sea level engines.

(iii) An intermediate altitude, taking into consideration the power characteristics of the engine.

b. Procedures - Sawtooth Climbs.

(1) Climb Technique. With the altimeter adjusted to a setting of 29.92 inches Hg (pressure altitude), the series of climbs should be initiated at a chosen altitude. Stabilize airspeed and power prior to recording data. The time at the beginning of each run should be recorded for weight-accounting purposes, and the stabilized climb should be continued for 3 minutes or 3000 feet minimum while holding airspeed substantially constant, Climbs should be conducted 90° to the wind, and alternately, on reciprocal headings to minimize the effects of windshear. Since the rate at which the altitude changes is the primary consideration of the test, particular care should be taken to observe the precise altimeter indication at precise time intervals. Time intervals of not more than 30 seconds are recommended for altimeter readings. Airspeed, ambient temperatures, r.p.m. and other engine power parameters also should be recorded, permissibly at longer intervals. Rates-of-climb/sink observed for test conditions should be greater than $\pm$100 ft./min. Rates of climb near zero tend to be unreliable. A running plot of altitude-versus-time provides an effective means of monitoring acceptability of test data as the run progresses, and a running plot of the observed rate of climb obtained for each airspeed enables similar monitoring of the sawtooth program. This procedure is recommended because of the opportunity it affords for promptly observing and economically rectifying questionable test results.

(2) Air Quality. In order to obtain accurate results, it is essential that the sawtooth climbs be conducted in smooth air. In general, the effects of turbulence are more pronounced in test data obtained at lower rates of climb and, when testing for compliance with minimum climb requirements, even slight turbulence may produce errors in observed climbs of such magnitude as to render the data inconclusive with respect both to rate of climb and best climb speed. Less obvious but equally unacceptable for climb testing is the presence of an inverse gradient in the ambient temperature.

(3) Test Airspeeds. The airspeeds selected for the sawtooth should bracket the best climb speed, which for preliminary purposes may be estimated as 140% of the power-off stalling speed. The lowest climb test speed should be as near the stalling speed as can be flown without evidence of buffeting, or necessity for abnormally frequent or excessive control movements, which might penalize the climb performance. Although the example shown in figure 25-l has 10 knot intervals, the interval between test speeds should be smaller at the lowspeed end of the range, and should increase as the speed increases. Suggested intervals are 5 knots at the low end, varying to 15 knots at the high end. In addition, the maximum level flight speed and V_S (or V_{MIN}) at the approximate midrange test altitude provide a useful aid in defining the curves in figure 25-2.

(4) Data Plotting. Sawtooth climb data is plotted on a graph using altitude and time as the basic parameters as shown in figure 25-l. After the sawtooth data has been plotted, -draw in the mean altitude line. A tangent line can now be drawn to each of the sawtooth climb curves at the mean altitude intersection. By determining the slope of the tangent lines, the observed rate of climb at the mean altitude for each sawtooth can be determined.

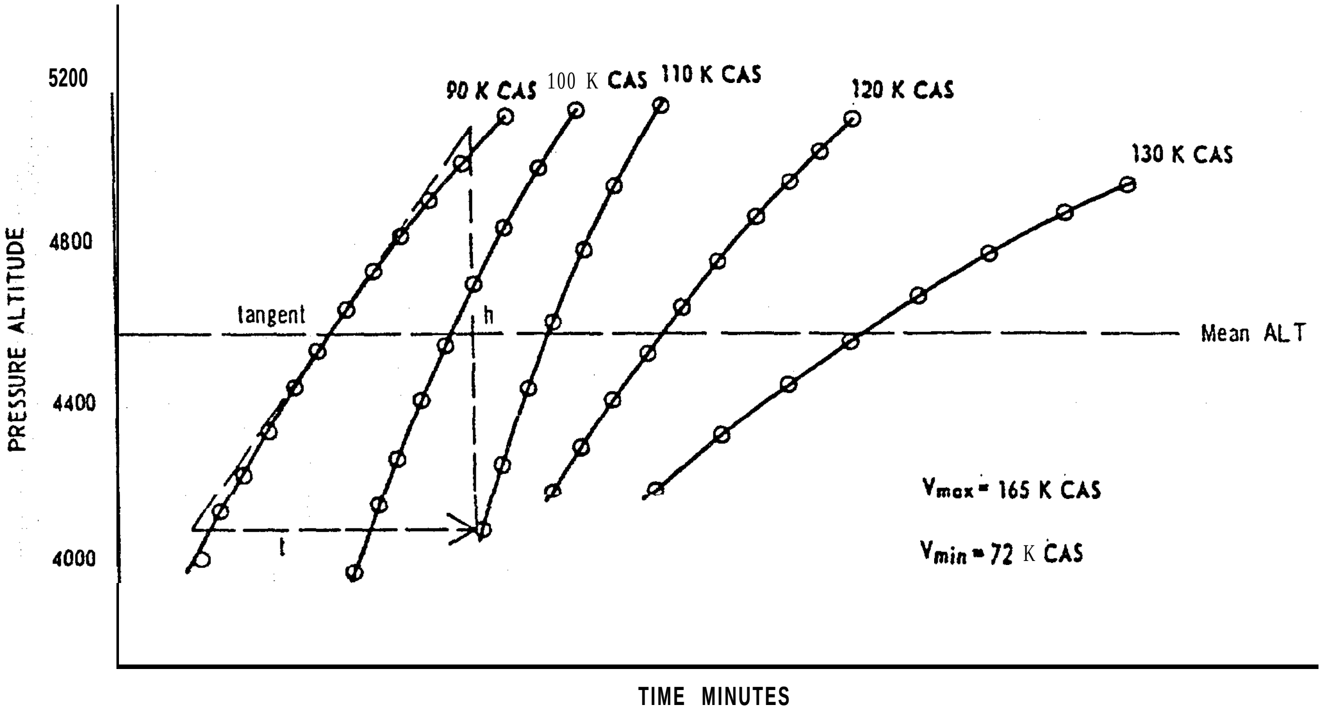


Figure 25-l - OBSERVED DATA

(5) Data Corrections. For the density altitude method of data reduction (see appendix 2), it is necessary to correct the data to standard atmospheric conditions, maximum weight, and chart brake horsepower before proceeding any further with the observed data. These corrections sometimes change the observed data a significant amount. The maximum level flight speed (V_{MAX}) data points should also be corrected to assist in defining the curves in figure 25-2.

(6) Plotting of Corrected Data. After the observed data has been corrected to the desired standards, it can be plotted as shown in figure 25-2 with the rate of climb versus calibrated airspeed at various density altitudes. It should be noted that the stall speed points are not usually true stabilized zero rate of climb data points. However, the stall speed points are useful in defining the asymptotic character of the left hand part of the curve.

(7) Speed Schedule Data Points. From the curves of figure 25-2, it is now possible to determine the airplane's best rate of climb speed schedule, V_Y. This *is* done by drawing a straight line through the peaks (highest rate of climb point) of each of the previously drawn curves of R/C vs. CAS. Also, it is possible to obtain from this graph the best angle of climb speed schedule V,. This is done by drawing tangent lines to the R/C vs. CAS curves from the graph origin and connecting each of the tangent intersect points with a straight line. It should be noted that the V_X and V_Y speed lines intersect at "zero" rate of climb. This is because zero rate of climb occurs *at* the airplane's absolute ceiling and V_X, V_Y, V_{MIN}, and V_{MAX} are all the same speed at this point.

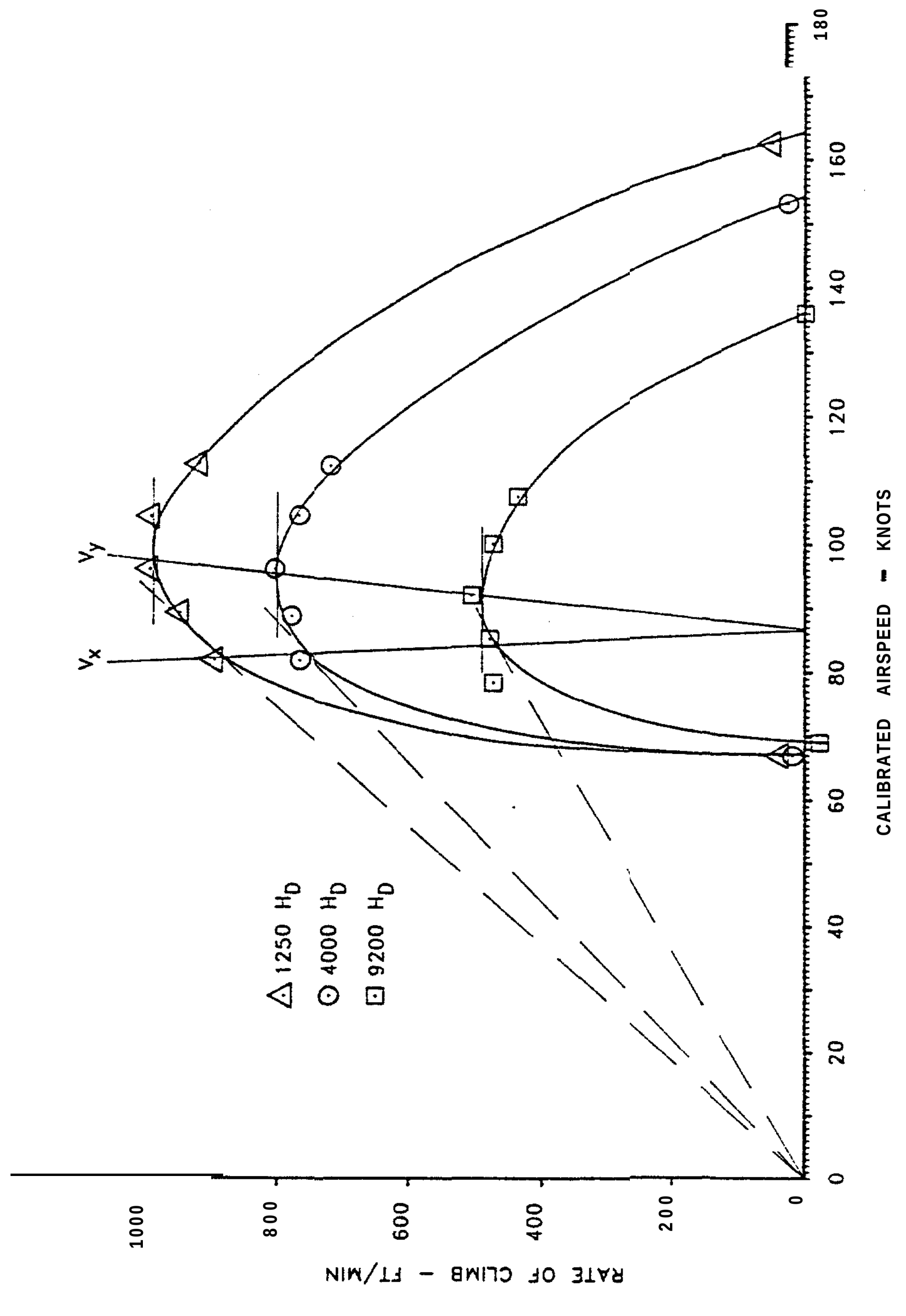


Figure 25-2 - RATE OF CLIMB VS. AIRSPEED

(8) Speed and Rate of Climb. Directly from information obtained from figure 25-2, it is possible to plot the climb performance of the airplane into a more usable form. By reading the rates of climb at the V_y intersect points and plotting them against altitude as shown in figure 25-3, it is possible to determine the rate of climb from sea level to the absolute ceiling.

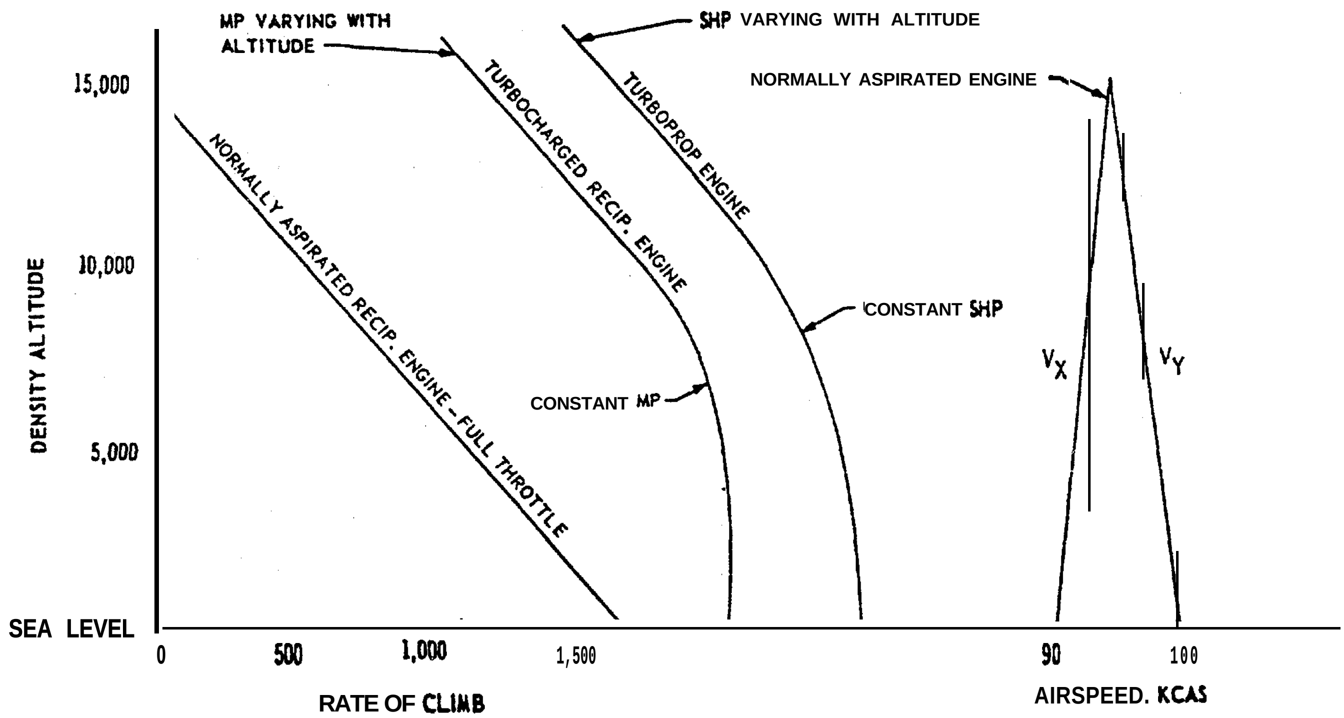


Figure 25-3 - RATE OF CLIMB AND SPEEDS

(9) Cowl Flap and Mixture. Cowl flaps should be in the position used for cooling tests. The mixture setting should be set to that used during the cooling test.

(10) Weight and C.G. For climb performance tests, the airplane's test weight, load distribution and engine power should be recorded. Usually, forward c.g. is critical for climb performance.

c. Extrapolation of Climb Data. The climb data expansion required by § 23.1587(a)(8) from sea level to 8000 feet and from ISA - 60°F to ISA + 40°F can be accomplished by the methods in appendix 2. Normally, the same method used for data reduction should be used for data expansion. Use caution in extrapolating beyond altitudes that have not been verified by flight tests. Generally, data should not be extrapolated more than 3000 feet in altitude.

d. Special Equipment or Instrumentation. Climb performance tests require a airspeed indicator, sensitive altimeter, and total air temperature indicator with known recovery factor. For reciprocating engine-powered airplanes, an induction temperature gauge, engine tachometer, manifold pressure gauge and cylinder head temperature indicator may be appropriate. For turbine-powered airplanes, indicat of power parameters, such as torque meter, EGT, N_1, N_2, and propeller r.p.m., may appropriate. A fuel counter and/or fuel flowmeter is useful. All instruments should be calibrated, and the calibration data should be included with the test records. In addition, a stopwatch and appropriate data recording board and forms required.

e. Climb Performance After STC Modifications. See appendix 10. Appendix 1 is not applicable to SFAR 23, SFAR 41, or commuter category airplanes.

26. SECTION 23.67 (as amended bv amendment 23-34) CLIMB: ONE ENGINE INOPERATIVE

a. Normal. Utilitv. and Acrobatic Category Airplanes.

(1) Performance Matrix. For all multiengine airplanes, § 23.67 require the one-engine-inoperative climb performance be determined in the specified configuration. The requirements of § 23.67 are summarized in the following table

Regulation	§ 23.67(a)	§ 23.67(b)(1)	§ 23.67(b)(2)	§ 23.67(c
Eng. Type	recip.	recip.	recip.	turbine
Weight (lbs)	over 6000	6000 or less	6000 or less	(all)
V_{SO} (kts)	(all)	over 61	61 or less	(all)
Required R/C (fpm)	.027 V_{SO}^2 at 5000 ft.	.027 V_{SO}^2 at 5000 ft.	no minimum required, but must be determined	*

*(i) 1.2% gradient or .027 V_{SO}^2 if greater, at 5000 feet Hp and 41°F (ISA) and

(ii) 0.6% gradient or .014 V_{SO}^2 if greater, at 5000 feet Hp and 81°F (ISA + 40°F).

(iii) The minimum climb gradients of (i) and (ii) *must* vary linearly between 40°F and 81°F and must change at the same rate up *to* the maximum operating temperature approved for the airplane.

(2) Range of Tests. The primary objective of the climb tests associate with this requirement is to establish the airplane's climb performance capability with one engine inoperative for altitudes between sea level and 8000 feet or high and temperatures from ISA - 60°F to ISA + 40°F. This is necessary to enable comparison with the prescribed climb requirement at 5000 feet altitude, and also for AFM presentation of climb performance data for altitudes and temperatures as prescribed in § 23.1587(c)(5). Secondary objectives are to establish the climb

speed to be used in the cooling tests required by §§ 23.1041 through 23.1047, including the appropriate speed variation with altitude, and to establish the speed for best rate of climb (or for minimum descent, as appropriate) which, irrespective of the speed used in demonstrating compliance with climb and cooling requirements, is required for presentation in the AFM in accordance with § 23.1587(c)(2).

(3) Turbine-Powered Airplane Off-load. For turbine-powered airplanes, offloading is permitted to meet the performance requirements. See discussion in paragraph 8 of this AC.

b. Procedure.

(1) Critical Engine. To accomplish these objectives, it is necessary that sawtooth climbs be conducted with the critical engine inoperative and with the prescribed configuration and power condition. The "critical-inoperative-engine" for performance considerations is that engine which, when inoperative, results in the lowest rate of climb. The critical engine should be determined by conducting a set of sawtooth climbs, one engine at a time. The relative power or thrust capabilities of each engine should be established so that comparative climb performance data can be corrected to equal engine powers.

(2) Test Technique. One-engine-inoperative climb tests should be conducted at airspeeds and at altitudes as outlined for all-engine climbs under § 23.65. The test technique and other considerations noted under § 23.65 also apply. In climb tests with one engine inoperative, however, trim drag can be a significant factor and one-engine-inoperative climb tests should be conducted on a steady heading with the wings laterally level or, at the option of the applicant, with not more than 5° bank into the good engine in an effort to achieve zero sideslip. A yaw string or yaw vane is needed to detect zero sideslip. The AFM should describe the method used, and the approximate ball position required to achieve the AFM performance.

c. Commuter Category Airplanes.

(1) Climb Gradient. The required climb gradients are specified in § 23.67(e).

(2) Climb Performance Methods. Climb performance should be determined in the configurations necessary, to construct the net takeoff flight path and to show compliance with the approach climb requirements of § 23.67(e)(3). Some net takeoff flight path conditions will require wings level climb data. See paragraph 22g(1). If full rudder with wings level cannot maintain constant heading, small bank angles into the operating engine(s), with full rudder, should be used to maintain constant heading. For all other conditions, climb performance may be determined with up to 5° bank into the good engine. Two methods for establishing the critical one-engine-inoperative climb performance follow:

(i) Method No. 1. Reciprocal heading climbs are conducted at several thrust-to-weight conditions from which the performance for the AFM is extracted.

(ii) Method No. 2. Drag polars and engine-out yaw drag data are obtained for expansion into AFM climb performance. See appendix 2. Reciprocal heading check climbs are conducted to verify the predicted climb performance.

(3) Landing Gear Position. The climb performance tests with landing gear extended in accordance with § 23.67(e)(1)(i) should be conducted with the landing gear and gear doors extended in the most unfavorable in-transit drag position. It has been acceptable to consider that the critical configuration is associated with the largest frontal area. For the landing gear, it usually exists with no weight on the landing gear. For gear doors, it is usually with all the gear doors open. If it is evident that a more critical transitional configuration exists, such as directional rotation of the gear, testing should be conducted in that configuration. In all cases where the critical configuration occurs during a transition phase which cannot be maintained except by special or extraordinary procedures, it is permissible to apply corrections based on other test data or acceptable analysis.

(4) Cooling Air. If means, such as variable intake doors, are provided to control powerplant cooling air supply during takeoff, climb, and en route flight, they should be set in a position which will maintain the temperature of major powerplant components, engine fluids, etc., within the established limits. The effect of these procedures should be included in the climb performance of the airplane. These provisions apply for all ambient temperatures up to the highest operational temperature limit for which approval is desired.

(5) Power. See paragraph 22b.

27. SECTION 23.75 (as amended by amendment 23-34) LANDING.

a. Explanation.

(1) Purpose. The purpose of this requirement is to evaluate the landing characteristics and to determine the landing distance. The landing distance is the horizontal distance from a point along the flight path 50 feet above the landing surface to the point where the airplane has come to a complete stop, or to a speed of 3 knots for seaplanes or amphibians on water.

(2) Companion Requirements. Sections 23.143(a)(5), 23.153, 23.231, and 23.233 are companion requirements, and normally, tests to determine compliance would be accomplished at the same time. Additionally, the requirements of § 23.473 should be considered.

(3) Approach. The steady gliding approach, the pilot skill, the conditions, the vertical accelerations, and the airplane actions in § 23.75(a), (b), and (c) are concerned primarily with not requiring particularly skillful or abrupt maneuvers after passing the 50-foot point. The phrase "steady gliding approach," taken in its strictest sense, means power off. However, it has generally been considered that some power may be used during a steady gliding approach to maintain at least 1.3 V_{S1} and control sink rate on final approach. For those airplanes using power during approach, power may be decreased after passing the 50-foot point and there should be no nose depression by use of the longitudinal control. For those airplanes approaching with power off, the longitudinal control may be used as necessary to maintain a safe speed for flare. In both cases, there should be no change in configuration and power should not be increased. The landing distance and the procedure specified in the AFM are then based on the power used for the demonstration. The power used and the technique used to achieve the landing distances should be clearly stated in the AFM. This applies to portions of the approach prior to and after the SO-foot height.

(4) Landing Gear Loads. Sink rate at touchdown during landing distance determination should be considered and should not exceed the design landing'gear loads established by § 23.473(d).

(5) Landing Distance Credit for Diskine Draa and Reverse Thrust. ‘Most turboprop installations embody provisions for reduction of propeller blade pitch from the "flight" regime to a "ground" regime to produce a significant level of disking drag and/or reverse thrust following touchdown on landing. For purposes of this discussion, disking drag is defined as not less than zero thrust at zero airspeed. Section 23.75(f) permits means other than wheel brakes *to* be used in determining landing distance, when the conditions specified in § 23.75(f) are met. One of the conditions is that the means be safe and reliable.

(i) Reliable. Compliance with the "reliable" provision of the rule may be accomplished by an evaluation of the pitch changing/reversing system in accordance with § 23.1309. The methods of AC 23.1309-l should be used in the evaluation even though type-certificated engine or propeller systems may not have been subjected to the AC 23.1309-l analysis during certification. Additionally, Society of Automotive Engineers (SAE) document ARP-926A, "Fault/Failure Analysis Procedure," will assist in conducting reliability and hazard assessments.

For commuter category airplanes, § 23.1309(d) requires the system to be designed to safeguard against hazards to the airplane in the event the system or any component thereof malfunctions or fails. An acceptable means for showing compliance with the requirement would be to conduct a Failure Modes and Effects Analysis (FMEA) of the-system. An acceptable analysis would show that the effects of any system or component malfunction or failure would not result in a hazard to the airplane and that the propeller reversing system is reliable. SAE document, ARP-926A, "Fault/Failure Analysis Procedure," contains acceptable criteria for conducting such an analysis.

Safe and reliable should also mean that it is extremely improbable that the system can mislead the flight crew or will allow asymmetric power settings, i.e., forward thrust on one engine vs. reverse thrust on the other. In achieving this level of reliability, the system should not increase crew work load or require excessive crew attention during a very dynamic time period in the landing phase. Also, the approved performance data should be such that the average pilot can duplicate this performance by following the AFM procedures.

(ii) Safe. Compliance with the "safe" provisions of § 23.75(f)(l) will require an evaluation of the complete system including operational aspects to ensure no unsafe feature exists.

(iii) Disking Drag: for Multiengine Installations with Flight Idle and Ground Idle. Symmetrical power/thrust may be used, with power levers at flight-idle position during air run, and at ground-idle position after touchdown. Procedures for consistently achieving ground idle should be established to ensure that the operational pilot gets the power lever back to ground idle, and thus providing consistent results in service. Two of the designs that have been found acceptable for ground-idle positioning are a dedicated throttle gate or tactile positioning of the throttle. In effecting thrust changes following touchdown, allowance should be made for any time delays that reasonably may be expected in service, or which may be necessary to assure that the airplane is firmly on the surface. See subparagraph b(2) for commuter category time delays. Associated procedures should be included in the AFM. If the disking drag or some other powerplant-related device has significant effect on the landing distance, the effect of an inoperative engine should be determined and published in the AFM Performance Section. The airplane should be satisfactorily controllable when landing under the most unfavorable conditions expected to be encountered in service; -including crosswinds, wet runway surfaces and one engine inoperative.

(iv) Diskine Drae for Single-Engine Installations with Flieht Idle and Ground Idle. Landing distances should be determined with the power levers at flight-idle position during air run, and at ground-idle position after touchdown. Procedures for consistently achieving ground idle should be established. Two of the designs that have been found acceptable for ground-idle positioning are a dedicated throttle gate or tactile positioning of the throttle. In effecting thrust changes following touchdown, allowance should be made for any time delays that reasonably may be expected in service, or which may be necessary to assure that the airplane is firmly on the surface. Associated procedures should be included in the AFM. The airplane should be satisfactorily controllable when landing under the most unfavorable conditions expected to be encountered in service, including crosswinds, and wet runway surfaces.

(v) Reverse Thrust for Multiengine Airplanes. In the approval of reverse thrust for turboprop airplanes, due consideration should be given for thrust settings allowed, the number of operating engines, and control of the aircraft with one engine inoperative. If landing distance depends on the operatio of any engine and if the landing distance would be noticeably increased (2% has been found acceptable) when a landing is made with that engine inoperative, the landing distance should be determined with that engine inoperative unless the use of compensating means (such as reverse thrust on the operating engine) will result in a landing distance not more than that with each engine operating. In effecting thrust changes following touchdown, allowance should be made for any time delays that reasonably may be expected in service, or which may be necessary to assure that the airplane is firmly on the surface. See subparagraph b(2) for commuter category time delays. Associated procedures should be included in the AFM. The airplane should be satisfactorily controllable when landing under the most unfavorable conditions expected to be encountered in service, including crosswinds, wet runway surfaces and one engine inoperative.

(vi) Reverse Thrust for Single-Engine Airplanes. In effecting thrus changes following touchdown, allowance should be made for any time delays that reasonably may be expected in service, or which may be necessary to assure that th airplane is firmly on the surface. Associated procedures should be included in th AFM. The airplane should be satisfactorily controllable when landing under the most unfavorable conditions expected to be encountered in service, including crosswinds, and wet runway surfaces.

(6) Balked Landing Transition. For the power conditions selected for th landing demonstration (except one engine inoperative) and other steady state conditions of speed and rate of sink that are established during the landing

approach, it should be possible, at the 50-foot point, to make a satisfactory transition to the balked landing climb requirement of § 23.77 using average piloting skill without encountering any unsafe conditions.

(7) Commuter Cateeorv.

(i) Temperature. Section 23.75(g)(l) requires landing distances be determined at standard temperature for the approved range of weights, altitudes, and wind conditions.

(ii) Wind Corrections. Correction for headwind and tailwind should be made in accordance with § 23.75(g)(3).

(iii) Expansion of Landing Data for a Range of Airport Elevations. When the basic landing tests are accomplished between sea level and approximately 3000 feet, the maximum allowable extrapolation limits are 6000 feet above and 3000 feet below the test field elevation. If it is desired to extrapolate beyond these limits, one of two procedures may be employed. These procedures are given in paragraph 19c(3)(i) and (ii).

b. Procedures.

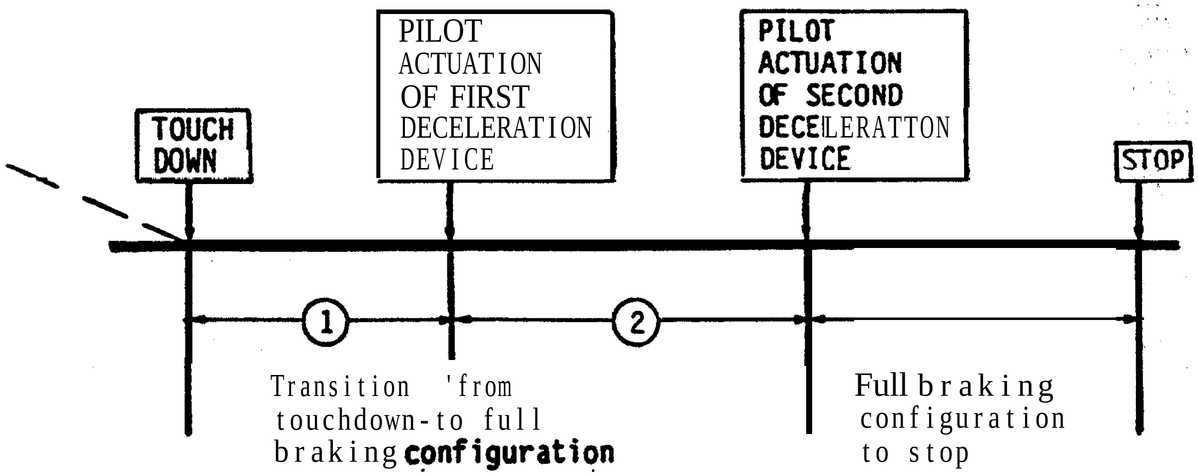
(1) Technique. The landing approach should be stabilized on target speed, power, and the airplane in the landing configuration prior to reaching the 50-foot height to assure stabilized conditions when the airplane passes through the reference height. The engine fuel control should be adjusted to the maximum flight-idle fuel flow permitted on airplanes in service unless it is shown that the range of adjustment has no effect on landing distance. A smooth flare should be made to the touchdown point. The landing roll should be as straight as possible and the airplane brought to a complete stop (or 3 knots for seaplanes) for each landing test. Normal pilot reaction times should be used for power reduction, brake application, and use of other drag/deceleration devices. See subparagraph b(2) for commuter category time delays. These reaction times should be established by a deliberate application of appropriate controls as would be used by a normal pilot in service, They should not represent the minimum times associated with the reactions of a highly trained test pilot.

(2) Commuter Category Time Delays.

(i) The time delays shown in figure 27-1 should be used.

(ii) For approved automatic deceleration devices (e.g., autospoilers, etc.) for which performance credit is sought for AFM data expansion, established times determined during certification testing may be used without the application of the l-second minimum time delay required in the appropriate segment above.

(3) Applicant's Procedures. The procedures to be followed should be those recommended by the applicant.



1 - This segment represents the flight test measured average time from touchdown to pilot actuation of the first deceleration device. For AFM data expansion, use 1 second or the test time, whichever is longer.

2 - This segment represents the flight test measured average test time from pilot actuation of the first deceleration device to pilot actuation of the second deceleration device. For AFM data expansion, see item 1 above.

Step 2 is repeated until pilot actuation of all deceleration devices has been completed and the airplane is in the full braking configuration.

Figure 27-1 - LANDING TIME DELAYS

(4) Number of Landings. For airplanes of more than 6000 pounds gross weight, at least six landings should be conducted on the same wheels, tires, and brakes to establish the proper functioning required by § 21.35(b). Six landings on the same wheels, tires, and brakes are recommended for airplanes of 6000 pounds or less.

(5) Winds. Wind velocity and direction should be measured adjacent to the runway during the time interval of each test run. See paragraph 6a(5) of this AC for wind velocity and direction tolerances.

(6) Weight. Landing tests should be conducted at maximum landing weight.

(7) Approach Angles Greater than 3°. For commuter category airplanes, if the applicant chooses an approach angle greater than 3°, landing distances which result from utilizing a 3° approach angle should be determined and published in the AFM to enable operators to comply with related operating rules.

c. Explanation (Commuter Category). Section 23.77(c)(1) states that the engines are to be set at the power or thrust that is available 8 seconds after initiation of movement of the power controls from minimum flight idle to the takeoff position. The procedures given are for the determination of this maximum power for showing compliance with the climb requirements of § 23.77.

d. Procedures (Commuter Category).

(1) Engine Trim. Trim turboprop engines to the minimum idle speed/power to be defined in the airplane maintenance manual.

(2) Engine Power Tests. Engine power tests should be conducted at the most adverse landing elevation and temperature condition, or the range of landing altitude and temperature conditions if the most adverse cannot be readily determined.

(i) In the critical air bleed configuration, stabilize the airplane in level flight with symmetrical power on all engines, landing gear down, flaps in the landing position, at a speed of 1.3 V_{SO}, at an altitude sufficiently above the selected test altitude so that time for descent to the test altitude with all throttles closed will result in minimum flight-idle power at test altitude.

(ii) Retard throttles to flight idle and descend at 1.3 V_S to approximately the test altitude. When the appropriate time has elapsed, advance throttle(s) in less than 1 second to obtain takeoff power.

(iii) The power that is available 8 seconds after the initiation of movement of the power controls from the minimum flight idle position is the maximum permitted for showing compliance with the landing climb of § 23.77 for each of the bleed combinations tested.

(iv) If AFM performance is presented so there is no accountability for various bleed conditions, the power obtained with the most critical air bleed should be used for landing climb performance for all operations, including the effects of anti-ice bleed.

e. Data Acquisition and Reduction. The information presented under § 23.65 applies to the balked landing climb.

29.-38. RESERVED.

Section 3. FLIGHT CHARACTERISTICS

39. SECTION 23.141 (as amended by amendment 23-17) GENERAL.

a. Explanation.

(1) Minimum Flight Characteristics. The purpose of these requirements is to specify minimum flight characteristics which are considered essential to safety for any airplane. This section deals primarily with controllability and maneuverability. A flight characteristic is an attribute, a quality, or a feature

of the fundamental nature of the airplane which is assumed to exist because the airplane behaves in flight in a certain consistent manner when the controls are placed in certain positions or are manipulated in a certain manner. In some cases, measurements of forces, control surface positions, or acceleration in pitch, roll, and yaw may be made to support a decision but normally it will be a pass/fail judgment by the FAA test pilot.

(2) Exceptional Skills. The phrase "exceptional piloting skill, alertness, or strength," is used repeatedly throughout the regulations and requires highly qualitative judgments on the part of the test pilot. The judgments should be based on the pilot's estimate of the skill and experience of the pilots who normally fly the type of airplane under consideration (that is, private pilot, commercial pilot, or airline transport pilot skill levels). Exceptional alertness or strength requires additional judgment factors when the control forces are deemed marginal or when a condition exists which requires rapid recognition and reaction to be coped with successfully.

(3) Stall Speed Multipliers. All flying qualities and trim speeds may be based on the forward c.g. stall speeds.

b. Procedures. None.

40.-44. RESERVED.

Section 4. CONTROLLABILITY AND MANEUVERABILITY

45. SECTION 23.143 (as amended by amendment 23-17) GENERAL.

a. Explanation.

(1) Temporary Control Forces. Temporary application, as specified in the table, may be defined as the period of time necessary to perform the necessary pilot motions to relieve the forces, such as trimming or reducing power. The values in the table under § 23.143 of Part 23 are maximums. There may be circumstances where a maximum pitch force less than 75 pounds is required for safety. For example, if a pilot is trying to overpower a nose-up autopilot malfunction during climb and reduce power at the same time, a maximum safe force may be less than 75 pounds. If it is found that a lower force is necessary for safety, then that lower force should be established under § 21.21(b)(2).

(2) Prolonged Control Forces. Prolonged application would be for some condition that could not be trimmed out, such as a forward c.g. landing. The time of application would be for the final approach only, if the airplane could be flown in trim to that point.

(3) Controllability. Controllability is the ability of the pilot, through a proper manipulation of the controls, to establish and maintain or alter the attitude of the airplane with respect to its flight path. It is intended in the design of the airplane that it be possible to "control" the attitude about each

failure occurred on an airplane utilizing an extremely large downspring, the loss of the downspring may result in a nose-up pitching moment at aft c.g. that could not be adequately countered by the basic pitch trim system.

b. Procedures. The wording of the regulation sufficiently describes the maneuvers required to show compliance. The selection of altitudes, weights, and c.g. positions to be flight tested by the FAA will depend on a study of the applicant's flight test report. Normally, the following combinations are checked during the certification tests:

(1) Altitude. A low altitude and an altitude near the maximum altitude capability of the airplane. A high altitude may not be needed for normally aspirated engine airplanes.

(2) Weight. Maximum gross weight for all tests, except where otherwise described in subparagraph (3) below.

(3) C.G. Section 23.145(a), most aft c.g. and most aft c.g. approved for any weight; § 23.145(b) 1 through 6, most forward and most aft c.g.; § 23.145(c), most forward c.g.; § 23.145(d), most forward c.g. and most forward c.g. approved for any weight; and § 23.145(e), both the forward and aft c.g. locations. Section 23.145(e) is sometimes more difficult to achieve at the aft c.g. than the forward limit, particularly if the airplane exhibits neutral to divergent phugoid tendencies.

(4) Power or Configuration. Pitching moments resulting from power or configuration changes should be evaluated under all conditions necessary to determine the most critical demonstration configuration.

c. Data Acquisition. No special instrumentation is required. The exception to this would be the lo-pound force in § 23.145(d) which should be measured with a force gauge. All longitudinal forces should be measured if the forces are considered marginal or excessive.

47. SECTION 23.147 (original issue) DIRECTIONAL AND LATERAL CONTROL.

a. Explanation.

(1) Engine Failure. Section 23.147(a) established a minimum maneuvering capability for an airplane that has sustained an engine failure after takeoff at a point in the climb-out path where the airplane has reached a speed of 1.4 V_{S1}, or VY (applicant's option). This test assures enough aileron and rudder control to prevent loss of control during mild maneuvering which may be operationally necessary during climb-out after takeoff.

(2) Yawed Flight. Section 23.147(b) is intended as an investigation for dangerous characteristics during sideslip, which may result from blocked airflow over the vertical stabilizer and rudder. Rudder lock and possible loss of directional control are examples of the kinds of characteristics the test is aimed at uncovering. Section 23.177 also addresses rudder lock. Compliance may be demonstrated if the rudder stop is reached prior to achieving either 15^{o} of heading

change or the 150-pound force limit providing there are no dangerous characteristics, The control stop serves more effectively than the 150-pound force to limit the pilot's ability to induce a yaw beyond that which has been demonstrated acceptable.

b. Procedures. The airplane configurations to be tested are:

(1) One engine inoperative and its propeller in the minimum drag position.

(2) The remaining engines at not more than maximum continuous power.

(3) The rearmost allowable center of gravity.

(4) The landing gear:

(i) retracted; and

(ii) extended.

(5) The flaps in the most favorable climb position.

(6) Maximum weight.

(7) Airplane trimmed in the test condition, if possible.

c. Data Acquisition. Data should be recorded as necessary to substantiate compliance. Forces may be estimated unless they are considered marginal.

48. SECTION 23.149 (as amended by amendment 23-21) MINIMUM CONTROL SPEED.

a. Background. Section 23.149 requires the minimum control speed to be determined. Section 23.1545 requires the airspeed indicator to be marked with a red radial line. Section 23.1583 requires that V_{MC} be furnished as an airspeed limitation in the AFM. These apply only to multiengine airplanes. A different V_{MC} airspeed will normally result from each approved takeoff flap setting. There are variable factors affecting the minimum control speed. Because of this, V_{MC} should represent the highest minimum airspeed normally expected in service. The variable factors affecting V_{MC} testing include:

(1) Engine Power. V_{MC} will increase as power is increased on the operating engine(s). Engine power characteristics should be known and engine power tolerances should be accounted for.

(2) Proneller of the Inoperative Reciprocating Engine. Windmilling propellers result in a higher V_{MC} than if the propeller is feathered. V_{MC} is normally measured with propeller windmilling unless the propeller is automatically feathered or otherwise driven to a minimum drag position without requiring pilot action.

b. Procedures. The applicant should fly each maneuver for which approval is sought. The FAA test pilot should then evaluate those maneuvers considered most critical.

c. Data Acquisition. A recently calibrated airspeed system, airspeed indicator; accelerometer, and tachometer should be provided by the applicant for the test airplane. The following should be recorded:

(1) Load factor.

(2) Entry airspeeds.

(3) Maximum airspeeds.

(4) Maximum r.p.m.

50. SECTION 23.153 (as amended by amendment 23-14) CONTROL DURING LANDINGS.

a. Explanation.

(1) Purpose. The purpose of this requirement is to ensure that airplanes over 6000 pounds gross weight do not encounter excessive control forces when approaching at a speed of 5 knots lower than normal landing approach speed. Also, a safe landing is required. Safe is considered to include having sufficient flare capability to overcome any excessive sink rate that may develop.

(2) Landing Requirements. Section 23.75 is a companion requirement and normally tests to determine compliance would be accomplished at the same time.

b. Procedures. The procedures applicable to § 23.75 would apply for § 23.153 except that for turbopropeller airplanes, the flight-idle fuel flow should be adjusted to provide minimum thrust.

51. SECTION 23.155 (as added by amendment 23-14) ELEVATOR CONTROL FORCE IN 'MANEUVERS.

a. Explanation.

(1) Stick Force Per G. The purpose of this requirement is to ensure that the positive stick force per g levels in a cruise configuration are of sufficient magnitude to prevent the pilot from inadvertently overstressing the airplane during maneuvering flight. The minimum maneuvering stability levels are generally found at aft c.g. loadings. Both aft heavy and aft light loadings should be considered. During initial inflight investigations, caution should be exercised in the event that pitch-up tendencies or decreasing stick force per g conditions occur.

(2) Buffet Boundaries. Low speed buffet onset may occur during high altitude investigations. A qualitative evaluation should be conducted beyond the boundary of buffet onset to ensure a capability to maneuver out of the buffet regime.

b. Procedures. Compliance with the requirements of § 23.155 should be demonstrated by measuring the normal acceleration and associated elevator stick force in a turn while maintaining the initial level flight trim speed. A descent may be required in the turn to maintain the level flight trim speed. As a minimum, the following conditions should be investigated in the cruise configuration; that is, flaps up and gear up (if retractable):

Condition	Power	Wings Level Trim Speed	Altitude
1	See note	Trimmed (but not to exceed V_{NE} or V_{MO}/M_{MO}	Low
2	See note	Trimmed	Altitude for highest dynamic pressure (q)
3	See note	V_A	Low
4	See note	V_A	Highest attainable approved altitude

NOTE: 75% maximum continuous power or maximum power selected by the applicant as an operating limitation during cruise (reciprocating engine) or maximum cruise power (turbine).

Compliance may be demonstrated by measuring the normal acceleration achieved with the limiting stick force (50 lbs. for wheel controls, 35 lbs. for stick controls) or by establishing the stick force per g gradient and extrapolating to the appropriate limit. Linear stick force gradients may be extrapolated up to 0.5g maximum. Nonlinear stick force gradients that indicate a possible gradient lightening at higher g levels should not be extrapolated more than 0.2g.

c. Data Acquisition and Reduction. The following should be recorded for each test condition:

(1) Wt./c.g.

(2) Pressure altitude.

(3) Outside air temperature (OAT).

(4) Engine power parameters.

(5) Trim setting.

(6) Elevator force.

(i) Flight Condition. Stabilize and trim carefully in the desired configuration at the desired flight condition.

(ii) Control Inputs. Smoothly apply alternating left and right rudder inputs in order to excite and reinforce the Dutch roll motion. Restrain the lateral cockpit control at the trim condition or merely release it. Continue the cyclic rudder pulsing until the desired magnitude of oscillatory motion is attained, then smoothly return the rudder pedals to the trim position and release them (controls free) or restrain them (controls fixed) in the trim position.

(iii) Input Frequency. The frequency with which the cyclic rudder inputs are applied depends on the frequency and response characteristics of the airplane. The test pilot should adjust the frequency of rudder pulsing to the particular airplane. The maximum Dutch roll response will be generated when the rudder pulsing is in phase with the airplane motion, and the frequency of the rudder pulses is approximately the same as the natural (undamped) frequency of the Dutch roll.

(iv) Spiral Motion. The test pilot should attempt to terminate the rudder pulsing so that the airplane oscillates about a wings-level condition. This should effectively suppress the spiral motion.

(v) Data. Obtaining quantitative information on Dutch roll characteristics from cockpit instruments and visual observations requires patience, particularly if the motion is heavily damped. If instrumentation is available to record sideslip angle versus time, the dynamic characteristics of the maneuver can readily be determined. The turn needle of the needle-ball instrument can also be used to observe 1/10 amplitude damping and the damping period.

(2) Steady Sideslip. The steady sideslip release can also be used to excite the Dutch roll; however, the difficulty in quickly returning the controls to trim and the influence of the spiral mode often precludes the gathering of good quantitative results. Full rudder or a very large amplitude sideslip may cause high loads on the airplane. The rudder pulsing technique usually produces better Dutch roll data. The steady sideslip release technique is performed as follows:

(i) Flight Condition. Stabilize and trim carefully in the desired configuration at the desired flight condition.

(ii) Control Input. Establish a steady heading sideslip of a sufficient magnitude to obtain sufficient Dutch roll motion for analysis. Utilize maximum allowable sideslip, using rudder as required. Stabilize the sideslip carefully. Quickly, but smoothly, return all cockpit controls to trim and release them (controls-free Dutch roll) or restrain them at the trim position (controls-fixed Dutch roll). Both methods should be utilized.

e. Stability Augmentation Systems (SAS). If the airplane is equipped with SAS, the airplane's characteristics should be evaluated throughout the approved operating envelope, following failures which affect the damping of the applicable mode. Following a SAS failure, if unsatisfactory damping is confined to an avoidable flight area or configuration, and is controllable to return the airplane to a satisfactory operational condition for continued safe flight, the lack of appreciable positive damping may be acceptable. Control of the airplane, including recovery, should be satisfactory using applicable control inputs. Following a critical failure, the degree of damping required should depend on the effect the oscillation will have on pilot tasks, considering environmental conditions. The capability to handle this condition should be demonstrated and evaluated. If a satisfactory reduced operational envelope is developed, appropriate procedures, performance, and limitations should be placed in the AFM. If a critical failure results in an unsafe condition, a redundant SAS may be required.

f. Data Acquisition and Reduction. Data acquisition for this test should support a conclusion that any short period oscillation is heavily damped and any Dutch roll is damped to 1/10 amplitude in 7 cycles.

76.-85. RESERVED.

Section 7. STALLS

86. SECTION 23.201 (as amended by amendment 23-14) WINGS LEVEL STALL.

a. Explanation.

(1) Stall. Section 23.201(c) defines when the airplane can be considered stalled, for airplane certification purposes. When either of two conditions occurs, whichever occurs first, the airplane is stalled. The conditions are:

(i) Uncontrollable downward pitching motion; or

(ii) the control reaches the stop.

Additionally, for airplanes with a stall barrier system, stick pusher operation has been considered as the stall speed. The term "uncontrollable downward pitching motion" is the point at which the pitching motion can no longer be arrested by application of nose-up elevator and not necessarily the first indication of nose-down pitch. Figure 17-1 shows a graphic representation of stall speed time histories for various configurations.

(2) Related Sections. The stalled condition is a flight condition that comes within the scope of §§ 23.49, 23.141, 23.143(b), 23.171, and 23.173(a). Section 23.143(b) requires that it be possible to effect a "smooth transition" from a flying condition up to the stalled flight condition and return without requiring an exceptional degree of skill, alertness, or strength. Any need for anticipated or rapid control inputs exceeding that associated with average piloting skill, is considered unacceptable.

(3) Recovery. The flight tests include a determination that the airplane can be stalled and flight control recovered, with normal use of the controls. Section 23.201(a) requires that for airplanes with independent roll and directional controls, it must be possible to produce and correct roll by unreversed use of the roll control and to produce and correct yaw by unreversed use of the directional control.

(4) Power. The propeller condition for the "power-off" tests prescribed by § 23.201(f)(6) should be the same as the "throttles closed" condition prescribed for the stalling speed tests of § 23.49, that is, propellers in the takeoff position, engine idling with throttles closed. The alternative of using sufficient power to produce zero propeller thrust does not apply to stall characteristics demonstrations.

(5) Altitude Loss. Altitude loss in excess of 100 feet and nose-down pitch in excess of 30" will be entered in the performance information section of the AFM in accordance with § 23.1587(a)(1) for the wings level stalls. The power used to regain level flight may not be applied until flying control is regained. This is considered to mean not before a speed of 1.2 V_{S1} is attained in the recovery dive.

(6) Configurations. Stall characteristics should be evaluated:

(i) At maximum to minimum weights at aft c.g. Aft light loadings may be the most critical in airplanes with high thrust to weight ratios.

(ii) With the elevator up stop set to the maximum allowable deflection.

(iii) With maximum allowable fuel unbalance.

(iv) At or near maximum approved altitude.

Also, airplanes with de-rated engines should be evaluated up to the critical altitude of the engine and at maximum altitude for which the airplane is to be certified. An airplane may be approved if it has stick pusher operation in one configuration, such as power on, and has acceptable stall characteristics for the remaining configurations.

b. Procedures.

(1) Emergency Egress. It is the responsibility of the applicant to provide adequate provision for crew restraint, emergency egress and use of parachutes (reference § 21.35(d)).

(2) **Buildup.** The FAA test pilot should carefully review the applicant's flight test report on stall and recovery characteristics. Generally, the stalls at more rearward c.g. positions are more critical than at the forward c.g. position. For this reason, the stall characteristics at forward c.g. should be investigated first. Altitude should be low enough to ensure capability of setting 75% power, but high enough to accomplish a safe recovery. The 75% power requirement means 75% of the rated power adjusted to the temperature and altitude test conditions. Reciprocating engine tests conducted on a hot day, for example, would require higher manifold pressures to be set so that when chart brake horsepower is adjusted for temperature, the result is 75% power.

(3) Pilot Determinations. During the entry and recovery, the test pilot should determine:

(i) That the stick force curve remains positive up to the stall (that is, a pull force is required) (reference § 23.171) when the trim speed is higher than the stall speed.

(ii) That it is possible to produce and correct roll and yaw by unreversed use of the rolling and directional control.

(iii) The altitude loss.

(iv) The pitch attitude below level.

(v) The amount of roll or yaw encountered during the recovery.

(vi) For two-control airplanes with interconnected lateral and directional controls, that it is possible to produce and correct roll up to the stall without producing what, in the opinion of the test pilot, is considered as "excessive yaw."

(4) Speed Reduction Rate. Section 23.201(c) requires the rate of speed reduction for entry not exceed one knot per second.

c. Data Acquisition and Reduction.

(1) Instruments. The applicant should provide a recently calibrated sensitive altimeter, airspeed indicator, accelerometer, outside air temperature gauge, and appropriate propulsion instruments; such as a torque meter or manifold pressure gauge and tachometer, a means to depict roll, pitch, and yaw angles; and force gauges when necessary.

(2) Data Recording. Automatic data recording is desirable, but not required, for recording time histories of instrumented parameters and such events as stall warning, altitude loss, and stall break. The analysis should show the relationship of pitch, roll, and yaw with respect to various control surface deflections. (See figure 17-1, stall speed determination.)

d. Stick Pusher.

(1) Background. Stick pushers have been installed in some airplanes which would not meet the requirements of § 23.201. This was accomplished under the provisions of § 21.21b(1). In some airplanes, operation of the stick pusher was not critical *to* safe flight and in others, stick pusher performance was essential to safe flight. In the latter case, the stick pusher typically functions as a stall barrier to prevent an airplane from entering flight regimes where a nonrecoverable stall could occur.

(2) Stall Prevention. There are two basic situations where a stick pusher would be necessary to show compliance with regulations. These are:

(i) Airplane Recoverable. The stall characteristics are investigated and during these tests, the airplane does not meet regulatory requirements but an inadvertent aerodynamic stall would *not* be catastrophic *or* inoperative. An "undue spinning" tendency would be considered to exist when other than normal use of the controls or exceptional skill, strength, or alertness were required to prevent spinning. In this case, reduction of power on the operating engine(s) during recovery, would be considered normal use of the controls.

(2) Power. Section 23.205(b)(4) states, ". . . the remaining engine(s) at 75% maximum continuous power or thrust, or the power or thrust at which the use of maximum control travel just holds the wings laterally level in the approach to stall . . . ." This section states that if use of maximum rudder or aileron control cannot maintain a wings level attitude prior to the stall, the power may be reduced from 75% MCP to a point where -maximum control travel just maintains wings level approaching the stall. The intent of this section is to check one-engine-inoperative stall characteristics, not engine-out lateral directional control capability which is covered under tests for V_{MC}.

(3) Propeller. If propeller feathering is available (manual or automatic), the propeller on the inoperative engine should be feathered.

b. Procedures. With the airplane trimmed longitudinally as specified in § 23.205(b)(6), with the critical engine inoperative, gear and flaps up, and 75% MCP on the operating engine, conduct a wings level stall by reducing the airspeed with the elevator control at a rate not greater than 1 knot per second. Keep the wings level and heading constant up to the stall. If there is insufficient control to do so, discontinue the maneuver and start over with reduced power on the operating engine. The power reduction should be just enough to allow keeping wings level and heading constant with full control travel. The operating engine(s) may be throttled back during the recovery, but care should be exercised to reduce previous control inputs as the power is reduced. Record the altitude loss incurred during the stall in compliance with § 23.1587(c)(1). The stalls should be accomplished in smooth air.

c. Data Acquisition. Same as for other wings level stalls of § 23.201.

89. SECTION 23.207 (as amended by amendment 23-7) STALL WARNING.

a. Explanation.

(1) Purpose. The purpose of this requirement is to ensure an effective warning in sufficient time to allow a pilot to recover from an approach to a stall without reaching the stall.

(2) Types of Warning. The effective warning may be from either aerodynamic disturbances or from a reliable artificial stall warning device such as a horn or a stick shaker. The aerodynamic warning is usually manifested by a buffet which vibrates or shakes the airplane. The type of warning should be the same for all configurations.

(3) Artificial Stall Warning. Stall warning devices may be used in cases where there is inadequate aerodynamic warning. The warning signal from the devices should be clear and distinctive and not require the pilot's attention to be directed inside the airplane. A stall warning light by itself is not acceptable.

(4) Margin. The stall warning margin between 5 knots and the greater of 10 knots or 158 of the stalling speed, is applicable when the speed is reduced at the rate of one knot per second. Stall warning margin at greater deceleration rates should not be less than 5 knots above the stall or above a speed at which warning would become objectionable in the normal operating range.

b. Procedures. The stall warning tests should be conducted in conjunction with the stall tests required by §§ 23.201 and 23.203.

c. Data Acquisition and Reduction. The speed at which stall warning is obtained should be recorded. This speed should be compared to the corresponding stall speed for the required stall warning margin of between 5 and the greater of 10 knots or 15% of the stalling speed above the corresponding stalling speed.

90.-99. RESERVED.

Section 8. SPINNING

100. SECTION 23.221 (as amended by amendment 23-7) SPINNING.

a. Explanation.

(1) Spin. A spin is a sustained auto rotation at angles of attack above stall. The rotary motions of the spin may have oscillations in pitch, roll and yaw superimposed upon them. The fully-developed spin is attained when the trajectory has become vertical and the spin characteristics are approximately repeatable from turn to turn. Some airplanes can autorotate for several turns, repeating the body motions at some interval, and never stabilize. Most airplanes will not attain a fully-developed spin in one turn.

(2) Category Spins. Section 23.221 addresses four situations:

(i) Normal category spins.

(ii) Utility category spins.

(iii) Acrobatic category spins.

(iv) Airplanes characteristically incapable of spinning.

(3) Incapable of Spinning. If an airplane cannot be induced to spin with attempted normal entries in accordance with paragraph 100b(6) and abnormal entries in accordance with paragraph 100c(3), it may be considered "characteristically incapable of spinning." Section 23.221(d) gives the configuration of the airplane for this test.

(4) Utility Category Airplanes. Utility category is used for airplanes intended for limited acrobatic operations in accordance with § 23.3. Spins (if approved for the particular type of airplane) are considered to be a limited acrobatic operation. This type of airplane may be approved in accordance with § 23.221(a), normal category, or with § 23.221(c), acrobatic category.

b. Discussion and Procedures Applicable to Both Normal and Acrobatic Category Spins.

(1) Weight and C.G. Envelope. See paragraph 7a of this AC for discussion of weight and c.g. envelope exploration.

(2) Control Deflections. Control surface deflections should be *set* to the critical side of the allowable tolerances, for example, if the rudder deflection is 20° ±2° left and right, 1 should be rigged at 18° left and right for the testing if the recovery phase is critical or 22° left and right if the entry phase is critical.

(3) Emergency Eqress. It is the responsibility of the applicant to provide adequate provision for crew restraint, emergency egress and use of parachutes (reference § 21.35(d)).

(4) Spin Recovery Parachutes.

(i) Spin recovery parachutes should be installed on all airplanes requiring spin testing for certification.

(ii) The anti-spin system installation should be carefully evaluat to determine its structural integrity, reliability, susceptibility to inadvertent or unwanted deployment or jettison, and adequate or redundant jettison capability. NASA recommendations should be referred to when evaluating the design of the chute deployment and jettison systems. The chute type, diameter, porosity, riser length and lanyard length should be determined in accordance with NASA recommended practices to maximize the probability the chute will be effective in spin recovery Chute sizes and particularly riser and lanyard lengths depend strongly on such aircraft variables as wing design, fuselage shape, tail arm, and mass properties. The sizes and lengths shown in the referenced NASA reports are for particular aircraft that were tested in the NASA Langley Spin Tunnel and will not necessaril be the correct size to recover other aircraft, even if the aircraft layout is similar. Appropriate NASA recommendations can be found in the following publications:

(A) NASA Technical Paper 1076, "Spin-Tunnel Investigation o the Spinning Characteristics of Typical Single-Engine General Aviation Airplane Designs," dated November 1977.

(B) NASA Technical Note D-6866, "Summary of Design Considerations for Airplane Spin-Recovery Parachute Systems."

(C) NASA Conference Paper, CP-2127, 14th Aerospace Mechanis Symposium, May 1980, entitled, "A Spin-Recovery System for Light General Aviation Airplanes."

The NASA documents are available from:

National Technical Information Service (NTIS).
5285 Port Royal Road
Springfield, Virginia 22161

(iii) Final certification of the spin characteristics should be conducted with the external spin chute removed unless it is determined that spin chute installation has no significant effect on spin characteristics.

(5) Build-Up. When any doubt exists regarding the recovery characteristics of the test airplane, a build-up technique should be employed consisting of spin entries and recoveries at various stages as the maneuver develops. Excessive aerodynamic control wheel back pressure indicates a possibility of unsatisfactory spin characteristics. Any control force lightening or reversal is an indication of possible deep stall entry. See subparagraph c(7) for definition of excessive back pressure. A yaw rate instrument is valuable in detecting progress toward a fully-developed spin condition or an uncontrollable maneuver. Unusual application of power or controls has sometimes been found to induce uncontrollable spins. Leading with elevator in recovery and cutting power as the airplane rolls into a spin have been known *to* induce uncontrollable spins.

(6) Entry. Spins should be entered in the same manner as the stalls in §§ 23.201 and 23.203 with trim at 1.5 V_{S1} or as close as practical. As the airplane stalls, with ailerons neutral, apply full-up elevator and full rudder in the direction of spin desired. Refer to paragraphs 100c and 100d for further discussion of spin entries.

(7) Recovery. Recoveries should consist of throttle reduced to idle, ailerons neutralized, full opposite rudder, followed by forward elevator control as required to get the wing out of stall and recover to level flight, unless the manufacturer determines the need for another procedure.

(8) Trimmable Stabilizer. For airplanes that trim with the horizontal stabilizer, the critical positions should be investigated.

(9) Altitude Engines. For airplanes with high-altitude engines, the effect of altitude should be investigated.

(10) Initial Investigation. In all cases, the initial spin investigation should be accomplished at as high an altitude above the ground as reasonably possible and a predetermined, pre-briefed "hard" altitude established to be used as the emergency egress altitude. In other words, if the airplane cannot be recovered by that altitude, all occupants should exit the airplane without hesitation. The altitude selected should take into account the opening characteristics of the parachutes, the difficulty of egress, the estimated number of turns to get out and the altitude loss per turn, the distance required to clear the airplane before deploying the parachutes, etc.

c. Discussion and Procedures Applicable to Normal Category Spins.

(1) Objective. The basic objective of normal category spin testing is to assure that the airplane will not become uncontrollable within one turn (or 3 seconds, whichever takes longer) if a spin should be encountered inadvertently and that recovery can be effected without exceeding the airplane design limitations. Type certification testing requires recovery capability from a one-turn spin while operating limitations prohibit intentional spins. This one-turn "margin of safety" is designed to provide adequate controllability when recovery from a stall is delayed. Section 23.221(a) does not require investigation of the controllability in a true spinning condition for a normal category airplane. Essentially, the test is a check of the controllability in a delayed recovery from a stall.

(2) Recovery from Spins with Normal Control Usage During Entry and Recovery. Normal category airplanes must recover from a spin after normal recovery control application is completed and one additional turn has passed. For example, if you are spinning left with ailerons neutral, recover by reducing power to idle, if not already at idle, apply full right rudder followed by forward elevator. At this point, start the count (heading, ground reference, etc.) for one turn. See subparagraph c(5) for use of flaps. Intentional, inadvertent, normal, up to 60° bank, and accelerated stalls should be considered.

(3) Recovery from Spins Following Abnormal Control Usage During: Entry and Recovery. Abnormal control usage should be evaluated during the spin to ensure that uncontrollable spins do not occur. The intent of these tests is to induce all of the types of control usage, whether they are right or wrong, that might be used during the operation of the airplane. These checks include, as a minimum, the effect of ailerons with and against the spin, the effect of elevator applied before the rudder at recovery, the effect of slow elevator release, the effect of entry attitude, the effect of power on at the entry, and the effect of power left on during the spin. Ailerons with and against the spin should be applied at entry and during spins. Elevator and rudder against the spin should be applied during the spin. Spinning should continue for up to three seconds, or for one full turn, while the effects of abnormal aerodynamic control inputs are observed. Apply normal recovery controls as outlined in subparagraph c(2). Up to two turns for recovery is considered acceptable.

(4) Spin Matrix. The effects of gear, flaps, power, accelerated entry, and control abuse should be investigated. A suggested matrix for spin investigation is given in figure 100-l. It is the responsibility of the applicant to explore all critical areas. It may be possible to eliminate the need to conduct some of the additional conditions once the airplane responses are known.

(5) Flaps. Section 23.221(a) specifies that for the flaps extended condition, the flaps may be retracted during the recovery. Flap retraction should not be initiated until after airplane rotation has ceased.

(6) Power. The use of power for spin entry for both normal and abnormal control use is recommended in order to determine the effects of power on spin characteristics and spin recovery procedures. For power on normal category spins, the throttle can be reduced to idle after one turn. I

(7) Back Pressure. Excessive back pressure is cause for noncompliance. Excessive back pressure is a judgment item and is defined as excessive force required to pitch the airplane down in recovery. Back pressure should not interfere with prompt and normal recovery.

d. Discussion and Procedures Annlicable to Acrobatic Category Spins.

(1) Objective. The basic objective of acrobatic category spin testing is to ensure that the airplane will not become uncontrollable when a spin is intentionally entered and:

(i) The controls are used abnormally (as well as normally) during the entry and/or during the spin;

(ii) the airplane will recover in not more than 1 1/2 turns after completing application of normal or manufacturer-prescribed recovery controls; and

(iii) no airplane limitations are exceeded, including positive maneuvering load factor and limit speeds.

(2) Pilot Training;. It is assumed that the pilot of the acrobatic category airplane that spins for six turns is doing so intentionally. If spinning is intentional, the pilot should have had proper instruction and proficiency to effect a proper recovery. The pilot should be expected to follow the published procedure to recover from this planned maneuver.

(3) Abnormal Control Usage. The discussion of "abnormal" use of controls in paragraph 100c(3) also applies to acrobatic category spins. Abnormal control usage should be evaluated at several points throughout the spin to ensure that uncontrollable spins do not occur. These checks include, as a minimum, the effect of ailerons with and against the spin, the effect of elevator applied before the rudder at recovery, the effect of slow elevator release, the effect of entry attitude, the effect of power on at the entry, and the effect of power left on during the spin. Spinning should continue for up to six full turns while the effects of abnormal aerodynamic control inputs are observed. The effect of leaving power on in the spin need only be examined by itself up to one full turn. Following abused control usage, reversion to normal pro-spin controls for up to two turns is acceptable, prior to the normal recovery control inputs, which must result in recovery in not more than two turns. In addition, going directly from the control abuse condition to the normal recovery control condition should not render the spin unrecoverable. For example, after evaluating the effect of relaxing the back stick input during the spin, it would be reasonable to expect the pilot to apply normal recovery use of rudder and elevator without first returning to full back stick.

(4) Flaps. If an acrobatic category airplane is placarded against intentional flaps down spins, then only normal category procedures need be used for the flaps down configurations.

(5) Snin Matrix. The effects of gear, flaps, power, accelerated entry, and normal and abnormal control use should be investigated. A suggested matrix f(spin investigation is given in figure 100-l. It is the responsibility of the applicant to explore all critical areas. It is necessary to expand the matrix to cover six-turn spins. The normal procedure is to continue the same process and a(one additional turn each time. It may be possible to eliminate the need to condu(some of the additional conditions once the airplane responses are known.

SPIN EVALUATION CONFIGURATION

Flight Condition / Spins from Wing Level Attitude	Spin Number	Flaps Up	Flaps Appch. (As Approp.)	Flaps Landing	Gear Up	Gear Down	Cowl Flaps Closed	Cowl Flaps As Required	Power Off	Power On	Forward C.G.	Aft C.G.	Lateral C.G.
Test with Normal Spin Controls	1	X			X		X		X		X	X	X
Left Spin 1 thru 6	2		X			X	X		X		X	X	X
	3			X		X	X		X		X	X	X
	4	X			X			X		X	X	X	X
	5		X			X		X		X	X	X	X
	6			X		X		X		X	X	X	X
Repeat 1 Through 6 from a right spin. Repeat 1 through 6 from left and right turning flight.													
Tests with Abnormal Spin Controls	7	X			X		X		X		X	X	X
Left Spin Aileron Against 7 Thru 12	8		X			X	X		X		X	X	X
	9			X		X	X		X		X	X	X
	10	X			X			X		X	X	X	X
	11		X			X		X		X	X	X	X
	12			X		X		X		X	X	X	X
Repeat 7 Through 12 From a Right Spin													
Left Spin Aileron with 13 Thru 18	13	X			X		X		X		X	X	X
	14		X			X	X		X		X	X	X
	15			X		X	X		X		X	X	X
	16	X			X			X		X	X	X	X
	17		X			X		X		X	X	X	X
	18			X		X		X		X	X	X	X
Repeat 13 Through 18 From a Right Spin. Repeat 7 Through 18 From Left & Right Turning Flight													

Figure 100-1 - SPIN EVALUATION CONFIGURATION MATRIX

(6) Spiral Characteristics. The acrobatic spin requirement stipulates that for the flap retracted six-turn spin, the spin may be discontinued after 3 seconds if spiral characteristics appear. This does not mean that the spin test program is discontinued. Each test point should stand alone and that spin be discontinued only after a spiral has developed. Limit speed should not be exceeded in the recovery. The airplane may be certificated as an acrobatic airplane whether or not it can spin a minimum of six turns.

(7) Recovery Placard. Section 23.1583(e)(3) requires that acrobatic airplanes have a placard listing the use of controls required to recover from spinning maneuvers. Utility category airplanes approved for spins should also have such a placard. Recovery control inputs should be conventional. If special sequences are employed, then they should not be so unique to create a recovery problem.

(8) Comnlex Instrumentation. When complex instrumentation is installed, such as wing tip booms or a heavy telemetry system, the instrumentation may affect the recovery characteristics. Critical spin tests should be repeated with the instrumentation removed.

e. Data Acquisition. The test airplane should be equipped with a calibrated airspeed indicator, accelerometer, and altimeter. Precise control of weight and balance and control deflections is essential.

f. Optional Equipment. In those cases where an airplane is to be certified with and without optional equipment such as deicing boots, asymmetric radar pods, outer wing fuel tanks, or winglets, sufficient tests should be conducted to ensure compliance in both configurations.

101.-105. RESERVED.

Section 9. GROUND AND WATER HANDLING CHARACTERISTICS

106. SECTION 23.231 (original issue) LONGITUDINAL STABILITY AND CONTROL.

a. Explanation.

(1) For landplanes, §§ 23.231(a) and 23.233 are companion requirements to § 23.75.

(2) For floatplanes, §§ 23.231(b) and 23.233 are companion requirements to § 23.75.

(3) The requirements for both landplanes and floatplanes apply to amphibians.

b. Procedures.

(1) Landplanes should be operated from all types of runways applicable to the type of airplane. Taxi, takeoff, and landing operations should be evaluated for acceptable characteristics. This should include idle power landings as well as landings and takeoffs with procedures used in §§ 23.75 and 23.51.

(2) Floatplanes should be operated under as many different water conditions as practical up to the maximum wave height appropriate to the type of airplane. Taxi (both displacement and step), takeoff, and landing operations should be evaluated for acceptable characteristics. This includes idle power landings as well as landings and takeoffs with procedures used under §§ 23.75 and 23.51.

(3) Amphibians should be evaluated in accordance with both items (1) and (2) above.

c. Procedures - Multiengine Airplanes. Evaluate all of the considerations contained in paragraph 106b, plus the effects of one engine loss during water operations.

d. Airplane Flight Manual (AFM). The AFM should include appropriate limitations plus demonstrated wind and sea state conditions.

107. SECTION 23.233 (original issue) DIRECTIONAL STABILITY AND CONTROL.

a. Explanation.

(1) Crosswind. This regulation establishes the minimum value of crosswind that must be demonstrated. Since the minimum required value may be far less than the actual capability of the airplane, higher values may be tested at the option of the applicant. The highest 90° crosswind component tested satisfactorily should be put in the AFM as performance information.

(2) Ground Loops. Section 23.233(a) does not preclude an airplane from having a tendency to ground loop in crosswinds, providing the pilot can control the tendency using engine power, brakes, and aerodynamic controls. The operating procedures should be placed in the AFM in accordance with § 23.1585(a).

(3) Controllability. Section 23.233(b) is not related to the crosswind requirement of 8 23.233(a). The demonstration of compliance with this requirement is accomplished into the wind. The test pilot is searching for any unusual controllability problems during landing and must use judgment as to what constitutes "satisfactorily controllable" since, at some point in the landing rollout, the aerodynamic controls may become ineffective.

(4) Taxi Controllability. Section 23.333(c) requires the airplane to have adequate directional controllability for taxi operations on land for landplanes, on water for floatplane's, and on land and water for amphibians.

(7) Speed Margins. Once it is established whether the airplane limit will be V_{NE} or V_{MO}, appropriate speed margins and markings may be evaluated. Th factors outlined in § 23.335 have been considered in establishing minimum speed margins during past type certification programs for the appropriate speeds. The factors to be considered are:

(i) Increment allowance for gusts (0.02M).

(ii) Increment allowance for penetration of jet stream or cold front (0.015M).

(iii) Increment allowance for production differences of airspeed systems (0.005M), unless larger tolerances or errors are found to exist.

(iv) Increment allowance for production tolerances of overspeed warning errors (0.01M), unless larger tolerances or errors are found to exist.

(v) Increment allowance ΔM, due to speed overshoot from M_{MO} established by upset during flight tests in accordance with § 23.253, should be added to the values for production differences and equipment tolerances, and the minimum acceptable combined value should not be less than 0.05M between M_{MO} and M_D. The value of M_{MO} should not be greater than the lowest value obtained from each of the following equations and from § 23.1505:

$$M_{MO} = MD - \Delta M - .005M - .01M$$

$$\text{or } M_{MO} = MD - .05M$$

(vi) Altitudes where q is limiting, the allowances of items (i) a (ii) are applicable and the Mach increment is converted to the units used for the limits.

(vii) At altitudes where q is limiting, the increment allowance fo production differences of airspeed systems and production tolerances of overspee warning errors are 3 and 6 knots, respectively, unless larger differences or errors are found to exist.

(viii) Increment allowance ΔV, due to speed overshoot from V_{MO} established by upset during flight tests in accordance with § 23.253, should be added to the values for production differences and equipment tolerances. The value of V_{MO} should not be greater than the lowest obtained from the following:

$$V_{MO} = V_D - \Delta V - 3 \text{ knots (prod. diff.)} - 6 \text{ knots (equip. tol.)}$$

or for V_{NO} airplanes:

$$V_{NO} = V_D - \Delta V - 3 \text{ knots (prod. diff.)} - 6 \text{ knots (equip. tol.)}$$

b. Procedures. Using the V_{MO}/V_{NO}, M_{MO}, or the associated design or demonstrated dive speeds determined in accordance with §§ 23.251, 23.335, and 23.1505, the airplane should be shown to comply with the high speed characteristics of § 23.253 and that adequate speed margins exist. Unless otherwise stated, the airplane characteristics should be investigated at any likely speed up to and including V_{NO}/V_{MO} or M_{MO}; and the recovery procedures used should be those selected by the applicant, except that the normal acceleration during recovery should be 1.5g (total),

(1) Center-of-Gravity Shift. The airplane should be upset by the center-of-gravity shift corresponding to the forward movement of a representative number of passengers depending upon the airplane interior configuration. The airplane should be allowed to accelerate for 3 seconds after the overspeed indication or warning occurs before recovery is initiated. Note the maximum airspeed. Do not exceed V_D/M_D.

(2) Inadvertent Control Movement. Simulate an evasive control application when trimmed at V_{MO}/M_{MO} by applying sufficient forward force to the elevator control to produce 0.5 g (total) for a period of 5 seconds, after which recovery should be effected at not more than 1.5g (total). Care should be taken not to exceed V_D/M_D during the entry maneuver.

(3) Gust Unset.

(i) Lateral Unset. With the airplane trimmed at any likely cruise speed up to V_{MO}/M_{MO} in wings level flight, perform a lateral upset to the same angle as that for autopilot approval, or to a maximum bank angle appropriate to the airplane, whichever is critical. Operationally, it has been determined that the maximum bank angle appropriate for the airplane should not be less than 45°, need not be greater than 60" and should depend upon airplane stability and inertia characteristics. The lower and upper limits should be used for airplanes with low and high maneuverability, respectively. Following this, with the controls free, the evaluation should be conducted for a minimum of 3 seconds after the calibrated value of V_{MO}/M_{MO} (not overspeed warning) or 10 seconds, whichever occurs first.

(ii) Longitudinal Unset. Perform a longitudinal upset as follows:

(A) Trim at V_{MO}/M_{MO} using power required for level flight but with not more than maximum continuous power. If the airplane will not reach V_{MO}/M_{MO} at maximum continuous power, push over to V_{MO}/M_{MO} and trim.

(B) If descending to achieve V_{MO}/M_{MO}, return to level flight without changing trim.

(C) Perform a longitudinal upset from normal cruise by displacing the attitude of the airplane in the range between 6-12°, which has been determined from service experience to be an optimum range. The value of displacement should be appropriate to the airplane type and should depend upon airplane stability and inertia characteristics. The lower and upper limits should be used for airplanes with low and high maneuverability, respectively.

(D) The airplane should be permitted to accelerate until 3 seconds after the calibrated value of V_{MO}/M_{MO} (not overspeed warning).

(iii) Two-Axis Upset. Perform a 2-axis upset consisting of a longitudinal upset combined with a lateral upset. Perform a longitudinal upset by displacing the attitude of the airplane as in the previous paragraph, and simultaneously perform lateral upset by rolling the airplane to the 15-25° bank angle range, which was determined to be operationally representative. The values of displacement should be appropriate to the airplane type and should depend upon airplane stability and inertia characteristics. The lower and upper limits should be used for airplanes with low and high maneuverability, respectively. The established attitude should be maintained until the overspeed warning occurs. The airplane should be permitted to accelerate until 3 seconds after the calibrated value of V_{MO}/M_{MO} (not overspeed warning).

(4) Leveling Off From Climb. Perform transition from climb to level flight without reducing power below the maximum value permitted for climb until the overspeed warning has occurred. Recovery should be accomplished by applying not more than 1.5g (total).

(5) Descent From Mach to Airspeed Limit Altitude. A descent should be initiated at M_{MO} and performed at the airspeed schedule defined in M_{MO} until the overspeed warning occurs. The airplane should be permitted to descend into the airspeed limit altitude where recovery should be accomplished after overspeed warning occurs by applying not more than 1.5g (total). The maneuver should be completed without exceeding V,.

122.-131. **RESERVED.**

(4) High Speed Malfunctions. When high speed malfunctions are introduced at V_{NE} or V_{MO}/M_{MO}, whichever is appropriate, the speed excursion, using the primary controls and any speed reduction controls/devices, should not exceed the demonstrated upset speed established under § 23.253 for airplanes with a V_{MO}/M_{MO} speed limitation and a speed midway between V_{NE} and V_D or those airplanes certified with a V_{NE} limitation.

(5) Speed Limitations. The use of a reduction of $V_{NE}/V_{MO}/M_{MO}$/ in complying with paragraph e(4) of this section is not considered acceptable, unless these new speeds represent limitations for the overall operation of the airplane.

(6) Forces. The forces encountered in the tests should conform to the requirements of § 23.143 for temporary and prolonged application. Also, see paragraph 45 of this AC.

140. SECTION 23.679 (original issue) CONTROL SYSTEM LOCKS. This subject is covered in AC 23.679-l.

141. SECTION 23.697 WING FLAP CONTROLS. (RESERVED).

142. SECTION 23.699 WING FLAP POSITION INDICATOR. (RESERVED).

143. SECTION 23.701 FLAP INTERCONNECTION. (RESERVED) .

144.-153. RESERVED.

Section 3. LANDING GEAR

154. SECTION 23.729 (as amended bv amendment 23-26) LANDING GEAR EXTENSION AND RETRACTION SYSTEM. This subject is covered in AC 23.729-l.

155. SECTION 23.735 BRAKES. (RESERVED).

156.-160. RESERVED.

Section 4. PERSONNEL AND CARGO ACCOMMODATIONS

161. SECTION 23.771 PILOT COMPARTMENT. (RESERVED).

162. SECTION 23.773 (as amended bv amendment 23-14) PILOT COMPARTMENT VIEW.

a. Pilot Position and View. For all evaluations, the pilot(s) should be seated at the intended design eye level as determined by an installed guide, if established. If an intended design eye level is not provided, the normal seating position should be used. The field of view that should remain clear should inclu the area specified in § 23.775(d).

b. External View. The external vision should be evaluated in all lighting and environmental conditions (day and night) with the airplane in all attitudes normally encountered. Attention to windshield distortion or refraction should especially be given to the view toward the approach and runway lights and the runway markings. Since glare and reflection often differ with the sun's inclination, consideration should be given to evaluating the cockpit at midday and in early morning or late afternoon. If the windshield is heated, evaluations should be conducted with heat on and off. Distortion and refraction should be so low as *to* prevent any unsafe condition, unusual eye strain or fatigue. "Safe operation," as used in § 23.773(a)(l) includes the ability to conduct straight ahead and circling approaches under all approved operating conditions, including operations in high humidity and icing conditions (if appropriate).

c. Night Approval. If night approval is requested, all lighting, both internal and external, should be evaluated in likely combinations and under expected flight conditions. Instrument lighting should be evaluated at night under a variety of ambient conditions, including night IFR. Windshield/side window reflections that distract from traffic avoidance, landing approach and landing are not acceptable. Landing lights, strobes, beacons, and recognition lights should be evaluated to ensure no adverse reflections or direct impingement into the cockpit.

d. Defog/Defrost/Deice. The adequacy of the defog/defrost/deice systems should be evaluated under the following conditions:

(1) Extended cold soak at maximum altitudes and minimum temperatures. The airplane should be exposed *to* a cold environment appropriate *to* minimum expected temperatures. The airplane should also be evaluated after remaining outside on a cold night.

(2) The airplane should be exposed to cold temperatures (cold soaked) and then descended into a warmer, more moist air mass to assess ability to maintain a clear field of view. To properly evaluate internal fogging, the test airplane should be flown at night at high altitude for at least two hours (or until the windshield temperature stabilizes). Then, using proposed AFM procedures, the airplane should be rapidly descended to an approach and landing in a high humidity area (recommend dewpoint at least 70°F). If manual clearing by the pilot(s) is required, it should be "easily" accomplished by an average pilot. The applicant should provide any special equipment required to accomplish the manual clearing. Repeated immediate clearings after manually wiping the windshield would not seem to fit the "easily cleared" requirements. The "easily cleared" aspects should also be evaluated considering the fact that the fogged windshield could frost under certain conditions. If manual clearing is required, pilot workload should be carefully evaluated if IFR approval is sought.

(3) Evaluations should be conducted in moderate rain, day and night (if approval is sought), takeoffs, landings, and taxi.

e. Two Pilot Airplanes. It is recommended that two pilot airplanes have pilot visibility in accordance with Society of Automotive Engineers (SAE) Aerospace Standard AS 580B, "Pilot Visibility from the Flight Deck Design Objectives for Commercial Transport Aircraft."

f. Cockpit Camera. An evaluation and documentation of the cockpit using a binocular camera is highly desirable.

163. **SECTION 23.777 COCKPIT CONTROLS. (RESERVED).**

164. **SECTION 23.803 (as added by amendment 23-34) EMERGENCY EVACUATION.** This subject is covered in AC 20-118A.

165. **SECTION 23.807 (as amended by amendment 23-34) EMERGENCY EXITS.** AC's 23.807-2 and 23.807-3 address this subject.

166. **SECTION 23.831 VENTILATION. (RESERVED).**

167.-175. **RESERVED.**

Section 5. PRESSURIZATION

176. **SECTION 23.841 (as amended by amendment 23-17) PRESSURIZED CABINS.** AC 23.841-1 addresses this subject.

177. **SECTION 23,843 PRESSURIZATION TESTS. (RESERVED).**

178.-188. **RESERVED.**

Figure 256-1 - CARBURETOR AIR HEAT RISE CALCULATIONS

NOTE: May be flown at only one altitude if O.A.T. of 30°F is Available	MINIMUM ALTITUDE						INTERMEDIATE ALTITUDE						
	Full Throttle or MC Power*		90% IAS of Column #1		80% IAS of Column #1		Full Throttle of MC Power*		90% IAS of Column #1		80% IAS of Column #1		Full or M P
Carburetor Air Heat Control Position	C	H	C	H	C	H	C	H	C	H	C	H	C
Pressure Altitude (ft.)	1500	→	→	→	→	→	5000	→	→	→	→	→	800
O.A.T. (°F)	83	83	83	83	83	83	72	72	72	72	72	72	6
C.A.T. (°F)	84	215	84	205	84	200	73	201	73	189	73	184	6
Heat Rise		132		122		117		129		117		112	
I.A.S. (M.P.H.)	105	99	95	92	84	82	96	88	87	78	77	70	9
R.P.M.	2850	2730	2690	2590	2430	2310	2800	2640	2555	2400	2410	2280	277
M.P. (In. Hg.)	26.4	25.7	24.0	23.5	22.0	21.3	23.5	22.8	19.6	19.3	19.0	18.5	21.
Indicated B.H.P.	144	132	120	112	105	99	125	114	92	85	76	72	11
Std. Temperature for Pressure Altitude (°F)	54	→	→	→	→	→	41	→	→	→	→	→	3
Temperature Correction Factor (See note 1)	.972	.872	.972	.879	.972	.882	.970	.870	.970	.879	.970	.882	.97
Actual B.H.P.	140	115	117	98.4	102	87.4	121	99.2	89	74.7	74	63.5	11
% Rated B.H.P. (See note 2)	100	82.2	83.5	70.2	72.8	62.4	86.4	71.0	63.5	53.4	52.8	45.3	78.
Throttle Position	FT	FT	P	P	P	P	FT	FT	P	P	P	P	FT

*Supercharged Engines Only

NOTE 1: Temperature Correction Factor $= \sqrt{\dfrac{\text{std temp } (^{\circ}F) + 460}{\text{CAT } (^{\circ}F) + 460}}$

NOTE 2: Rated BHP = 140

NOTE 3: Circled numbers indicate data plotted on figure 256-2.

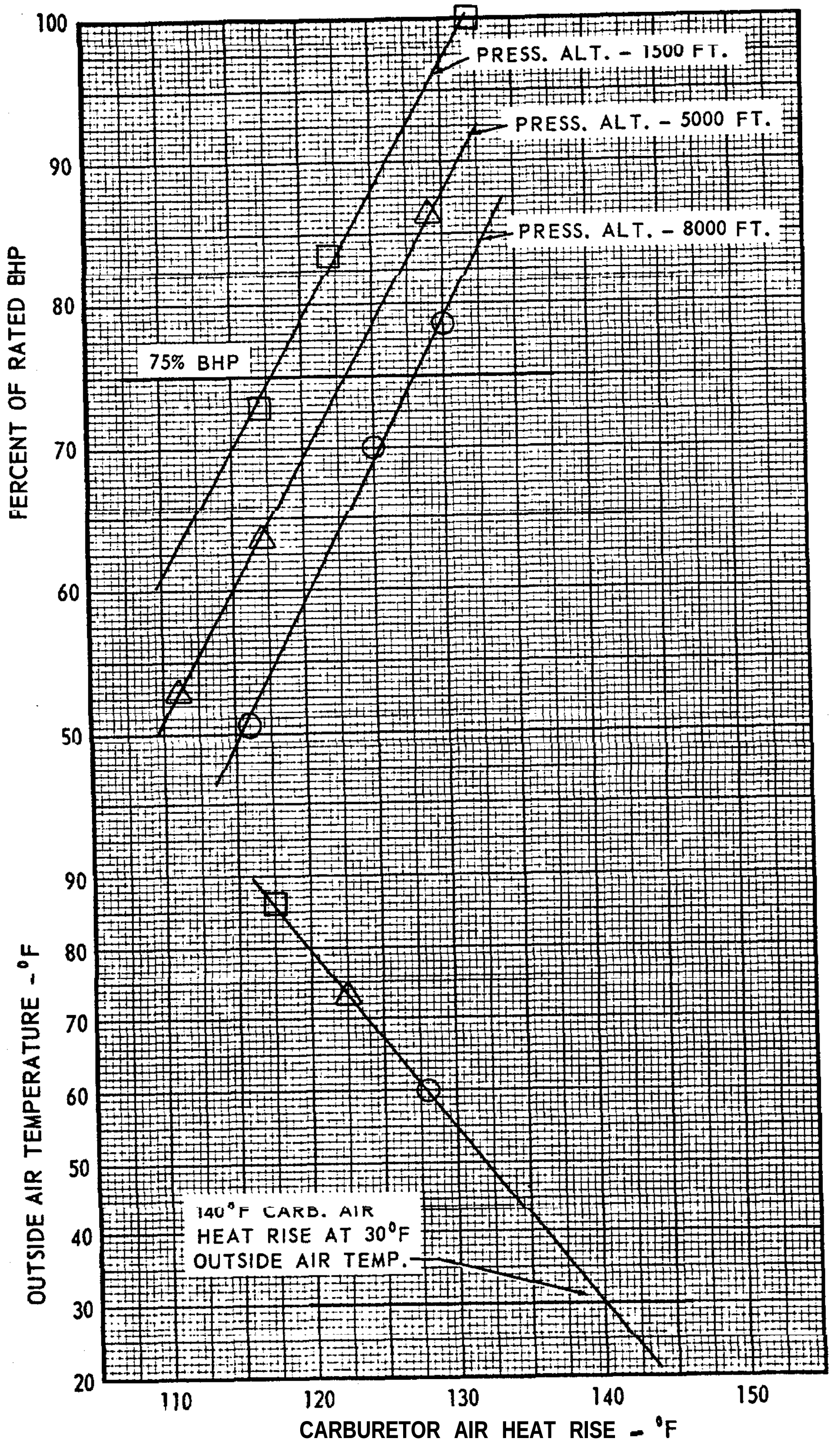


Figure 256-2 - CARBURETOR AIR HEAT RISE PLOTS

10 hours, the radial error should not exceed 2 n.m. per hour of operation on a 95% statistical basis. For flights longer than 10 hours, the error should not exceed ±20 n.m. cross-track or ±25 n.m. along-track error. A 2 n.m. radial error is represented by a circle, having a radius of 2 n.m., centered on the selected destination point.

(ii) Electromagnetic Compatibility (EMC). With all systems operating in flight, verify, by observation, that no adverse effects are present in the required flight systems.

(13) Doppler Navigation.

(i) Doppler navigation system installed performance should be evaluated in accordance with AC 121-13.

(ii) Electromagnetic Compatibility (EMC). With all systems operating in flight, verify, by observation, that no adverse effects are present in the required flight systems.

(14) Audio Interphone Systems.

(i) Acceptable communications should be demonstrated for all audio equipment including microphones, speakers, headsets, and interphone amplifiers. All modes of operation should be tested, including operation during emergency conditions (that is, emergency descent, and oxygen masks) with all engines running, all pulse equipment transmitting and all electrical equipment operating. If aural warning systems are installed, they should be evaluated, including distinguishing aural warnings when using headphones and with high air noise levels.

(ii) Electromagnetic Compatibility (EMC). With all systems operating during flight, verify, by observation, that no adverse effects are present in the required flight systems.

(15) Electronic Flight Instrument Systems. See AC 23.1311-1. a

(16) VLF/Omega Navigation Systems. See AC's 20-101B, 90-79, 120-31A, and 120-37.

(17) LORAN C Navigation Systems. See AC 20-121A.

(18) Microwave Landing Systems. (RESERVED).

288. SECTION 23.1303 (prior to amendment 23-17) FLIGHT AND NAVIGATION INSTRUMENTS.

a. Explanation. Section 23.1303, as amended by amendment 23-17, provides for a speed warning device for all turbine engine-powered airplanes. Section 23.1303(e) should not be applied to Amended Type Certificates or Supplemental Type Certificates (STCs) with a certification basis prior to amendment 23-17, where a reciprocating engine is replaced with a turbine engine under § 21.101(b), since it would normally increase the level of safety above that established by the regulations referenced on the original type certificate. An aural speed warning device may be required on such airplanes only if an unsafe condition would exist without one.

b. Procedure. The following procedure should be used to determine whether an unsafe condition exists when converting a reciprocating engine small airplane to turbine engine(s):

(1) Determine if there is any distinctive natural warning that becomes unmistakably evident if the limiting speed (V_{NO}, V_{MO}) is exceeded by 6 knots or the limiting Mach (M_{MO}) is exceeded by .01. Aerodynamic buffet by itself is not considered an adequate natural warning of an overspeed condition (see paragraph 121a(6)).

(2) The airplane should be evaluated for compliance with the high-speed characteristics of § 23.253. An acceptable means of demonstrating compliance is provided in this section.

(3) When evaluating the specific upset conditions for determining the need for an overspeed warning device, record the airspeed at the end of the specified delay times. If an overspeed warning system is not installed, or there is no natural warning, the time delays shall begin at the airspeed defined for overspeed warning, that is, V_{NO}/M_{MO} plus 6 knots or M_{MO} plus 0.01M. If the airplane will accelerate to more than the previous V_{NE} or to a speed more than half way between V_{MO}/M_{MO} and V_D/M_D, then an overspeed warning will be required.

(4) V_{MO}/M_{MO} is established by procedures defined in § 23.335(b) and an upset maneuver that is attitude, time, thrust, and drag sensitive. All established recognition and recovery procedures for determining the acceptability of a given V_{MO}/M_{MO} under §§ 23.251 and 23.253 are predicated upon the pilot receiving a clear and distinct warning slightly past the established V_{MO}/M_{MO}. Definite recognition establishes the beginning of time delay for 3 seconds prior to recovery initiation, thus providing an adequate normal operation margin for recovery. If an airplane accelerates rapidly enough during this time delay, to exceed the previously established V_{NE}, or half the distance between V_{MO}/M_{MO} and V_D/M_D, the time remaining to recover is considered inadequate to meet the criteria envisaged in the procedures prescribed in § 23.335(b). This would be considered as an unsafe feature under the provisions of § 21.21.

289. SECTION 23.1303 (as amended by amendment 23-17) FLIGHT AND NAVIGATION INSTRUMENTS.

a. Free Air Temperature (FAT). Section 23.1303(d) requires that turbine engine-powered airplanes have a free air temperature indicator or an air temperature indicator that provides indications that are convertible to free air. The temperature pickup can be calibrated against a test pickup of known characteristics, or by flying at various speeds at constant altitude, or by tower fly-by. This calibration is frequently done in conjunction with one or more of the airspeed calibration methods described in paragraph 302 of this AC. The constant altitude and tower fly-by calibration methods are described in Air Force Technical Report No. 6273 (see appendix 2, paragraph f(2) of this AC).

b. Remaining Flight and Navigation Instruments. (RESERVED).

CHAPTER 6. OPERATING LIMITATIONS AND INFORMATION

Section 1. GENERAL

365. SECTION 23.1501 (as amended by amendment 23-21) GENERAL.

a. Explanation.

(1) Flight Crew Information. This section establishes the obligation inform the flight crew of the airplane's limitations and other information necessary for the safe operation of the airplane. The information is presented in th form of placards, markings, and an approved AFM. Appendix 4 can be used to assi in determining which methods of presentation are required.

(2) Minimum Limitations. Sections 23.1505 thru 23.1527 prescribe the minimum limitations to be determined. Additional limitations may be required.

(3) Information Presentation. Sections 23.1541 thru 23.1589 prescrib how the information should be made available to the flight crew.

b. Procedures. None.

366. SECTION 23.1505 (as amended by amendment 23-7) AIRSPEED LIMITATIONS.

a. Explanation. This section establishes the operational speed limitatio which establish safe margins below design speeds. For reciprocating engine-powe airplanes there is an option. They may either establish a never-exceed speed (V and a maximum structural cruising speed (V_{NO}) or they may be tested in accordanc with § 23.335(b)(4) in which case the airplane is operated under a maximum operating speed concept (V_{MO}/M_{MO}). For turbine-powered airplanes, a V_{MO}/M_{MO} sho be established. Tests associated with establishing these speeds are discussed under § 23.253, High Speed Characteristics.

b. Procedures. None.

367. SECTION 23.1507 (original issue) MANEUVERING SPEED. This regulation is se explanatory.

368. SECTION 23.1511 (original issue) FLAP EXTENDED SPEED. This regulation is self-explanatory.

369. SECTION 23.1513 (original issue) MINIMUM CONTROL SPEED. This regulation i self-explanatory.

370. SECTION 23.1519 (original issue) WEIGHT AND CENTER OF GRAVITY. This regulation is self-explanatory.

371. SECTION 23.1521 POWERPLANT LIMITATIONS. (RESERVED).

372. SECTION 23.1523 (as amended by amendment 23-21) MINIMUM FLIGHT CREW. All configurations evaluated should be carefully documented.

373. SECTION 23.1523 (as amended bv amendment 23-34) MINIMUM FLIGHT CREW.

a. Discussion. The following should be considered in determining minimum flight crew.

(1) Basic Workload Functions. The following basic workload functions should be considered:

(i) Flight path control.

(ii) Collision avoidance.

(iii) Navigation.

(iv) Communications.

(v) Operation and monitoring of aircraft controls.

(vi) Command decisions.

(vii) Accessibility and ease of operation of necessary controls.

(2) Workload Factors. The following workload factors are considered significant when analyzing and demonstrating workload for minimum flight crew determination:

(i) The impact of basic airplane flight characteristics on stability and ease of flight path control. Some factors such as trimmability, coupling, response to turbulence, damping characteristics, control breakout forces and control force gradients should be considered in assessing suitability of flight path control. The essential elements are the physical effort, mental effort and time required to track and analyze flight path control features and the interaction with other workload functions.

(ii) The accessibility, ease, and simplicity of operation of all necessary flight, power, and equipment controls, including emergency fuel shutoff valves, electrical controls, electronic controls, pressurization system controls, and engine controls.

(iii) The accessibility and conspicuity of all necessary instruments and failure warning devices such as fire warning, electrical system malfunction, and other failure or caution indicators. The extent to which such instruments or devices direct the proper corrective action is also considered.

(iv) For reciprocating-engine-powered airplanes, the complexity and difficulty of operation of the fuel system with particular consideration given to the required fuel management schedule necessitated by center of gravity, structural, or other airworthiness considerations. Additionally, the ability of each engine to operate continuously from a single tank or source which is automatically replenished from other tanks if the total fuel supply is stored in more than one tank.

FAA approval is indicated by the signature of the Aircraft Certification Office Manager, or his representative, on the cover page and a page effectivity table so that it is clear to the operational pilot exactly which pages are applicable and the date of approval.

(2) Section 23.1581(b)(2). The AFM must have an approved limitations section and this approved section must contain only limitations (no procedures, performance, or loading information allowed). The limitations section must be identified and clearly distinguished from other parts of the AFM. The remainder of the manual may contain a mixture of approved and unapproved information, without segregation or identification. However, the other required material (procedures, performance, and loading information) must be determined in accordance with the applicable requirements of Part 23. The meaning of "acceptable," as used in § 23.1581(b)(2)(ii), is given in the preamble to amendment 23-21. The applicable portion of the amendment 23-21 preamble is as follows:

> "In finding that a manual is acceptable, the FAA would review the manual to determine that the required information is complete and accurate. The manual would also be reviewed to ensure that any additional information provided by the applicant is not in conflict with required information or contrary to the applicable airworthiness requirements."

The indication of approval for the approved section should be as discussed in the preceding paragraph. GAMA Specification No. 1 has been found to comply with the provisions of § 23.1581(b)(2).

c. Part 36 Noise Limitations and/or Procedures.

(1) If the applicant chooses the § 23.1581(b)(1) option, operating limitations required by Part 36 should be placed in the Operating Limitations portion of the AFM. Any Part 36 procedures should be placed in the Operating Procedures portion of the AFM.

(2) If the applicant chooses the § 23.1581(b)(2) option, the approved AFM should contain the following approved, but separate, portions:

(i) Operating limitations prescribed in § 23.1583. Note that § 23.1581(b)(2)(i) limits the information in this portion to that prescribed in § 23.1583. Since the present Part 36 limitation is a weight limitation, the Part 36 limitation may be included.

(ii) Operating procedures prescribed by Part 36. Section 36.1581(a) requires Part 36 procedures to be approved.

d. STC Procedures.

(1) AFM Options. STC applicants are responsible for preparing an AFM supplement when the airplane has been modified in such a manner that limitations, procedures, or performance have been changed. The supplement should be prepared

in accordance with the guide provided in appendix 5 and reflect the necessary supplemental information. Alternately, the applicant may choose to prepare a new AFM. If the applicant selects the latter option, the new AFM replaces the original AFM in its entirety.

(2) Performance. Concerning performance, if the STC applicant does not want credit for any increased performance and demonstrates that the performance meets or exceeds all basic airplane performance, a general statement to that effect would be satisfactory.

e. Additional Information. Some additional information items that are required for safe operation because of unusual design, operating, or handling characteristics are as follows:

(1) Operation of strobe lights during flight through fog, clouds, or flying closely under an overcast.

(2) Use of carburetor heat.

(3) Restricted use of flaps during sideslips.

(4) Management of propeller pitch when Beta Range is provided.

(5) Procedures for the temporary use of sand screens and engine heater devices.

(6) Unusual feathering design where propeller will not feather with throttle closed.

(7) Scheduling for fuel flow by engine mixture leaning procedure.

(8) Unusual spin recovery techniques.

(9) Wheelbarrowing characteristics.

(10) Pilot-induced oscillations or oscillations caused by turbulence, particularly on swept-wing airplanes.

(11) Repressurization procedures prior to landing.

(12) Procedures for operation of automatic devices; that is, wing levelers, mach trim, yaw damper, etc.

(13) Procedures for operation of integrated flight guidance and control systems. This should include proper pilot response to cockpit warnings, diagnosis of system failures, discussion of possible pilot-induced flight control system problems, and use of the system in a safe manner.

411. SECTION 23.1583 (as amended bv amendment 23-34) OPERATING LIMITATIONS.

a. Limitations Section. The purpose of the Limitations Section is *to* present the limitations applicable to the airplane model by serial number, if applicable, as established in the course of the type certification process in determining compliance with Parts 23 and 36 of the FAR. The limitations should I presented without explanation other than those explanations prescribed in Parts 2

(i) Contents of the checklists are the responsibility of the operator.

(ii) The FAA-approved AFM takes precedence in case of conflicting checklist information.

(6) Automatic Display. Automatic display of appropriate checklists during conditions of engine failure, generator failure, etc., will require a review based upon the specific application involved. Approval of the checklist content, malfunction prioritization, and operation is required.

413. SECTION 23.1587 (as amended bv amendment 23-34) PERFORMANCE INFORMATION.

a. Performance Information. This section contains the airworthiness performance information necessary for operation in compliance with applicable performance requirements of Part 23, applicable special conditions, and data required by Part 36. Additional information and data essential for implementing special operational requirements may be included. Performance information and data should be presented for the range of weight, altitude, temperature, airplane configurations, thrust rating, and any other operational variables stated for the airplane.

b. Normal, Utility, and Acrobatic Category Airplanes. See GAMA Specification 1.

c. Commuter Category Airplanes.

(1) General. Include all descriptive information necessary to identify the precise configuration and conditions for which the performance data are applicable. Such information should include the complete model designations of airplane and engines, the approved flap, sweep, or canard settings, definition of installed airplane features and equipment that affect performance, together with the operative status thereof (e.g., anti-skid devices, automatic spoilers, etc.). This section should also include definitions of terms used in the Performance Section (e.g., IAS, CAS, ISA, configuration, net takeoff flight path, icing conditions, etc.), plus calibration data for airspeed (flight and ground), Mach number, altimeter, ambient air temperature, and other pertinent information.

(2) Performance Procedures. The procedures, techniques, and other conditions associated with attainment of the flight manual performance data should be included. Performance procedures may be presented as a performance subsection or in connection with a particular performance graph. In the latter case, a comprehensive listing of the conditions associated with the particular performance may serve the objective of "procedures" if sufficiently complete.

(3) Thrust or Power Setting. Thrust or power settings should be provided for at least takeoff and maximum continuous and the methods required to obtain the performance shown in the AFM. If appropriate, these data may be required to be shown for more than one thrust setting parameter.

(4) Takeoff Speeds. The operational takeoff speeds V,, V,, and V_2 should be presented together with associated conditions. Section 23.1587(d)(6) requires the speeds be given in CAS. Since the aircrew flies IAS, the airspeeds should also be presented in IAS. The V, and V_R speeds should be based upon "ground effect" calibration data; the V_2 speeds should be based upon "free air" calibration data.

(5) Takeoff Distance. Takeoff distance should be shown in compliance with § 23.59.

(6) Climb Limited Takeoff Weight. The climb limited takeoff weight which is the most limiting weight showing compliance with § 23.67 should be provided.

(7) Miscellaneous Takeoff Weight Limits. Takeoff weight limits, for any equipment or characteristic of the airplane configuration which imposes an additional takeoff weight restriction, should be shown (e.g., tire speed limitations, brake energy limitations, etc.).

(8) Takeoff Climb Performance. For the prescribed takeoff climb airplane configurations, the climb gradients should be presented together with associated conditions. The scheduled climb speed(s) should be included.

(9) Takeoff Flight Path Data. The takeoff flight paths of § 23.61 *or* performance information necessary to enable construction of such paths, together with associated conditions (e.g., procedures, speed schedules), should be presented for the configurations and flight path segments existing between the end of the prescribed takeoff distance and the point of attaining the en route climb configuration airspeed or 1500 feet, whichever is higher.

(10) En Route Climb Data. The climb gradients prescribed in § 23.67 should be presented together with associated conditions, including the speed schedule used.

(11) Balked Landing Climb Limited Landing Weight. The climb limited landing weight which is the most limiting weight showing compliance with § 23.77.

(12) Approach Climb Limited Landing Weight. The climb gradient determined in § 23.67(e)(3) should be presented. The required climb gradient may limit the landing weight.

(13) Landing Approach Speeds. The scheduled speeds associated with the approved landing distances should be presented together with associated conditions.

(14) Landing Distance. The landing distance from a height of 50 feet should be presented together with associated ambient temperature, altitude, wind conditions, and weights up to the maximum landing weight. Operational landing distance data should be presented for smooth, dry, and hard-surfaced runways. At the option of the applicant, with concurrence by the FAA, additional data may be presented for wet or contaminated runways, and for other than smooth, hard-surfaced runways. At the option of the applicant, FAR 135 landing field length and alternate landing field length may be presented.

From this plot the profile drag coefficient (C_{DP}) can be determined graphically and Oswald's efficiency factor (e) can be calculated.

$$e = \frac{C_L^{\,2}}{\left(C_D - C_{DP}\right) 3.1416 \left(\frac{b^2}{S}\right)} \quad \text{or} \quad e = \frac{\Delta C_L^{\,2} / \Delta C_D}{3.1416 \left(\frac{b^2}{S}\right)}$$

Where: b = wing span - feet
S = wing area -- square feet

d. Standard Day Correction. Since the $C_L^{\,2}$ vs. C_D data was developed from test day conditions of weight, altitude, temperature, and power, calculations will be required to determine standard day conditions.

$$R/C = \frac{(THP_A - THP_R)\ 33{,}000}{W_C\ (AF)}$$

Where: THP_A = thrust horsepower available

THP_R = thrust horsepower required

W_C = aircraft weight to which correction is to be made (pounds)

AF = acceleration factor (see paragraph b)

$$THP_A = BHPc\ (\eta_P)$$

Where: BHPc = chart brake horsepower at test day density altitude (see appendix 1)

η_P = propeller efficiency

$$THP_R = \frac{\sigma\ (V_T)^3\ C_{DP}\ S}{96209} + \frac{(0.2883)\ (W_C)^2}{e\ \sigma\ b^2\ V_T}$$

Where: σ = atmospheric density ratio

V_T = true airspeed - knots

C_{DP} = profile drag coefficient

S = wing area - square feet

e = efficiency factor

b = wing span - feet

W_C = aircraft weight to which correction is to be made - pounds

e. Expansion to Nonstandard Conditions. The methods in paragraph d can be used to expand the climb data by choosing weight, altitude, temperature, and the corresponding power available.

f. References. The following references may be of assistance in cases where compressibility drag is a factor, climb angles are greater than 15°, or if the reader wishes to review the basic derivations of the drag polar method:

(1) "Airplane Aerodynamics and Performance" by C. Edward Lan and Jan Roskam. Published and sold by:

Roskam Aviation and Engineering Corporation
Route 4, Box 274
Ottawa, Kansas 66067

(2) Air Force Technical Report No. 6273, "Flight Test Engineering Handbook," by Russell M. Herrington, et. al., dated May 1951. Corrected and revised June 1964-January 1966. Refer *to* NTIS No. AD 636 392. Available from:

National Technical Information Service (NTIS)
5285 Port Royal Road
Springfield, Virginia 22161

2. DENSITY ALTITUDE METHOD. This method is an alternate to the Drag Polar Method. The Density Altitude Method is subject to the same cautions as the Drag Polar Method. Item numbers 1, 2, 6, 9, 12, 17, 18, and 19 are observed during flight *tests* and the remaining items are calculated.

Item No.	Item
1	Pressure Altitude (Hp) -- feet
2	Outside Air Temperature -- °F
3	Atmospheric Density Ratio -- σ
4	Density Altitude (Hd) -- feet. $Hd = 145539\left[1-(\sqrt{\sigma})^{.4699}\right]$
5	Std. Temp. @ Hp (T_s) -- °F + 460
6	IAS -- knots
7	CAS -- knots
8	$TAS = \dfrac{⑦}{\sqrt{③}}$
9	Observed rate of climb -- ft./min.
10	$\dfrac{T}{T_s} = \left(\dfrac{② + 460}{⑤}\right)$

Item No.	Item
11	Actual R/C = (9) x (10)
12	Test Weight, w -- lbs.
13	$\Delta R/C\Delta_w = (11)\left(1 - \frac{(12)}{W_C}\right)$
	where W_C = aircraft weight to which correction is to be made
14	$q\pi e\, b^2 = \frac{(7)^2 \pi e\, b^2}{295}$
	where b = wing span in feet e = Oswald's efficiency factor (0.8 may be used if a more exact value cannot be determined)
15	AD, $= \left(\frac{W_C^2 - (12)^2}{(14)}\right)$
16	$\Delta(R/C)\Delta D_i = \frac{101.27\,(15)\,(8)}{W_S}$
17	Calibrated RPM (reciprocating engine)
18	Calibrated MP (reciprocating engine)
19	Inlet air temperature
20	Test day BHP corrected for temperature from appendix 1 at Hp
21	BHPc corrected for temperature from appendix 1 at Hd
22	η_p -- propeller efficiency (obtain from propeller manufacturer or may be estimated)
23	$\Delta THP = (22)\left((21) - (20)\right)$
24	$\Delta(R/C)\Delta p = \frac{(23) \times 33{,}000}{W_C}$
25	$R/C_{std} = (11) - (13) - (16) + (24)$

Items 4, 7, and 25 are used to plot figure 25-2.

APPENDIX 5. GUIDE FOR PREPARING AIRPLANE FLIGHT MANUAL AND PILOT'S OPERATING HANDBOOK SUPPLEMENTS

1. INTRODUCTION. An applicant is responsible for preparing an Airplane Flight Manual (AFM) supplement when the airplane has been modified in such a manner that limitation, procedures, performance, or loading information have changed. The supplement should be prepared to reflect this supplemental information. If there is no change in one of the sections, it should so state.

a. Pilot's Operating Handbook Sunnlements. Refer to GAMA Specification No. 1 Revision No. 1.

b. AFM Sunnlements. Refer to paragraph 2 below and sample AFM.

2. GENERAL.

a. Enter name and address of applicant and document number (if used).

b. Enter make and model of the airplane. Multiple models may be used.

c. Enter registration number. Note: if more than one airplane is to be approved under this supplemental type certificate, leave this space blank on the master copy of the supplement so it can be filled in for each airplane as the modification is accomplished.

d. Enter airplane serial number. This number is on the airplane data plate. Note: If more than one airplane is to be approved under this supplemental type certificate, leave this space blank on the master copy of the supplement so it car be filled in for each airplane as the modification is accomplished. If only one airplane is to be approved, add "only" after the serial number.

e. Enter original AFM date or reissue date (if applicable).

f. Enter the type of modification or equipment installed.

g. Enter approval basis such as: Form 337, specification item number, Supplemental Type Certificate Number, etc.

h. Enter any changed or additional limitations as a result of the modification. Follow the format of the basic AFM. If no change, state "NO CHANGE."

i. Enter any change in or additional procedures as a result of the modification. Follow the format of the basic AFM. This section may be divided into Normal and Emergency Procedures, if necessary. If no change, state "NO CHANGE."

j. Enter any change in performance as a result of the modification. If no change, state "NO CHANGE." In some cases it is possible to show a statement similar to the following, "The performance of this airplane equipped with the Continental E-225-8 engine and Beech Model 215 propeller is equal to or better than the performance as listed in the original FAA-approved AFM."

k. Enter any change in the loading instructions, if necessitated by the change.

l. Copy this item as shown on the sample AFM Supplement leaving a blank space for typing of the ACO Manager's name below the signature line.

m. Type as shown on sample AFM Supplement leaving a blank space so date of approval can be added.

n. If the supplement requires more than one page, a cover page should be prepared in accordance with page 3 of this appendix, except that items (h), (i), (j), and (k) should be on page 2 or subsequent. Each page should have: (1) the name and address of applicant and document number; (2) AFM supplement for Make and Model; (3) "FAA-approved" and "date" of approval, and (4) page number as (Page 1 of 3).

o. For those airplanes without flight manuals, and placards are not appropriate, the document should be labeled a Supplemental Airplane Flight Manual and arranged and worded as necessary with reference to the appropriate markings and placards. Identification of the material as Limitations, Procedures, or Performance should be clearly presented.

p. If applicant revises the AFM supplements, pertaining to one airplane model, a log of revisions may be added, as follows:

LOG OF REVISIONS

Revision No.	Pages Affected	Description	FAA-Approved	Date

NOTE. The revision page should immediately follow the cover page.

q. Vertical bars should be placed in the margin of the revised pages to indicate changed material.

Name ______________________________

(a)

Address ______________________________

Supplement No. ______________________

FAA-APPROVED

AIRPLANE FLIGHT MANUAL SUPPLEMENT

FOR

_________(b)__________
Make and Model Airplane

Reg. No. _____(c)_____

Ser. No. _____(d)_____

This supplement must be attached to the FAA-approved Airplane Flight Manual dated _______(e)_______ when __________(f)__________ is installed in accordance with _______________(g)_______________. The information contained in this document supplements or supersedes the basic manual only in those areas listed. For limitations, procedures, performance, and loading information not contained in this supplement, consult the basic airplane flight manual.

I. LIMITATION: (h)

II. **PROCEDURES:** (i)

III. PERFORMANCE: (j)

IV. LOADING INFORMATION: (k)

FAA-Approved __________(1)__________

Manager, Aircraft Certification Office
Federal Aviation Administration
City, State

DATE ______________________
(m)

Revised ____________________
(If applicable)

Page 1 of ____________________
(n)

APPENDIX 10. GUIDE FOR DETERMINING CLIMB PERFORMANCE AFTER STC MODIFICATIONS (not applicable to SFAR 23. SFAR 41. or to commuter category)

1. INTRODUCTION. Section 23.1587 requires certain performance information to be included in the AFM. These include the climb requirements and rate of climb information as specified by §§ 23.65, 23.67, and 23.77. Additionally, some turbi powered airplanes may have the maximum weight of § 23.1583(c) limited by climb performance. If an airplane is modified externally (and/or an engine change) and the changes are deemed significant enough to produce measurable effects, any appropriate requirements and information should be determined for inclusion in th AFM supplement.

2. GENERAL. Supplemental Type Certificates involve modifications to inservice airplanes which may, for one reason or other, not exactly match Type Design climb performance data which was determined and published in the AFM. These effects ca be the result of engine power deteriorations, added antennae, exterior surfaces n polished or smooth, propeller nicks, or a variety of other reasons. In addition, it is difficult and costly to obtain calibrations of engine power output which ma have been available during the original certification process. The extent of performance degradation observed after incorporating external modifications could be partially due to deficiencies present in the airplane prior to modification. other instances, the results of performance measurements indicate that there is little or no effect from the modification and the test airplane closely matches t values contained in the basic AFM, even though analysis indicates some degradatio For either of these situations, the actual loss in performance could be skewed or masked by these other variables. For these reasons, any climb performance measurements conducted as part of an STC modification should be conducted such th the actual effects of the modification are identified. One effective means of accomplishing this is to measure the performance of the unmodified airplane, then repeat the same tests with the external modifications incorporated. Any variatic from the basic performance predictions due to engine power or other variables wil be minimized or eliminated.

3. PROCEDURE FOR EXTENDING CLIMB PERFORMANCE TO ADDITIONAL AIRPLANES. The conditions to be evaluated should be identified from a review of the applicable regulations and related to the modifications to be incorporated. The instruments which are to be involved in the flight tests should have recent calibrations. Th airspeed system should be verified to be in agreement with the basic airplane calibrations.

Prior to modifications, conduct a series of climbs utilizing the general procedur and information presented in paragraphs 25, 26, and 28 of this AC. Test speeds a other conditions may be abbreviated to those which are presented in the AFM. The AFM can also be utilized as a guide to identify how climb performance is predicted to vary with altitude and other conditions. Results should be corrected to some standard in accordance with appendix 2, or some other acceptable method. The bef and after tests should be conducted, as nearly as possible, at the same airplane weight.

After the modification, the series of climbs conducted above should be repeated. Apply the same procedures and corrections as before. Corrected results of climbs before and after the modification should be compared by plotting the combined results. The performance in the AFM is useful in identifying how climb performance was predicted to change with altitude and temperature. It is likely that there will be some scatter and variations in the final results. With a limited amount of testing, the effects of the modification should be determined conservatively and identified in a manner suitable for presentation in the AFM supplement.

4. "ONE ONLY" AIRPLANE. Often, there are circumstances where the full range of performance tests before and after the STC modification are not warranted. These might include:

a. A limited effectivity such as a one only modification.

b. An excessively conservative reduction in published climb performance which would not limit normal operations of the airplane and limitations are not affected.

The conditions to be evaluated should be identified from a review of the applicable regulations and related to the modifications to be incorporated. The instruments which are to be involved in the flight tests should have recent calibrations. The airspeed system should be verified to be in agreement with the basic airplane calibrations.

If the reduction in climb performance is not limiting, then it may be acceptable to conduct tests of the modified airplane only and provide analysis which could be used to support and compare with the tests. Values of climb degradation should be selected which are sufficiently conservative to overcome any variations or discrepancies which may have been present. This should not involve any requirements of § 23.1583. The information required by § 23.1587, however, could be excessively conservative without degrading normal operations of the airplane in service.

For example, analysis predicts that a particular modification will reduce the one engine inoperative climb performance by 50 feet per minute, and limited testing shows a reduction of 30 feet per minute. In order to overcome the introductory considerations and variables, a degradation in climb performance should be obviously conservative. The higher of the two rate of climb degradation values could be doubled to achieve this objective. For this example, the AFM supplement would reflect a degradation in one engine inoperative climb performance of 100 feet per minute.

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